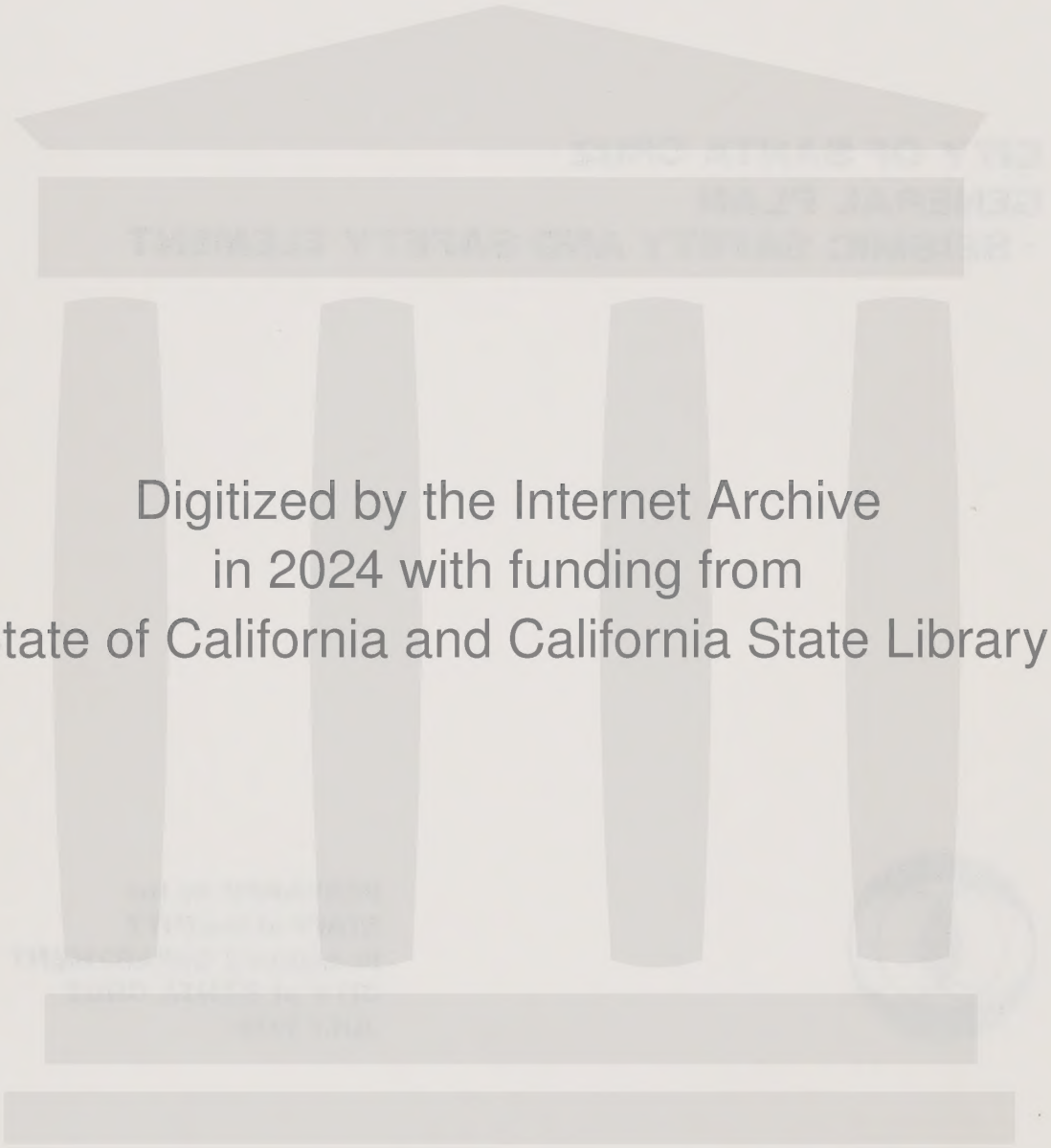
CITY OF SANTA CRUZ
GENERAL PLAN
· SEISMIC SAFETY AND SAFETY ELEMENT

CITY OF SANTA CRUZ
GENERAL PLAN
· SEISMIC SAFETY AND SAFETY ELEMENT

PREPARED by the
STAFF of the CITY
PLANNING DEPARTMENT
CITY of SANTA CRUZ
JULY 1976



RESOLUTION CPC-76-20

A RESOLUTION OF THE CITY PLANNING COMMISSION OF THE CITY OF SANTA CRUZ AMENDING THE GENERAL PLAN FOR THE FUTURE DEVELOPMENT OF SANTA CRUZ, TO INCLUDE THE SEISMIC SAFETY AND SAFETY ELEMENT

WHEREAS, the Planning Commission carefully reviewed and evaluated the draft Seismic Safety and Safety Element which addresses itself to the seismic safety and flood, fire, and geologic safety needs of the existing City of Santa Cruz; and

WHEREAS, the Planning Commission considered evidence presented thereon, and did find and determine that said amendment to the General Plan for the future development of the City of Santa Cruz does constitute a proper amendment to said General Plan, and meets the requirements of State law; and

WHEREAS, The Planning Commission did hold a public hearing on said document, as required by law, on May 27, 1976, at which time all members of the community were afforded the opportunity to comment on and question the proposed policies; and

WHEREAS, The Planning Commission considered the environmental impacts of the policies contained within the Seismic Safety and Safety Element and determined that said policies will not have a significant environmental effect, and a negative declaration is the appropriate California Environmental Quality Act environmental determination;

NOW, THEREFORE, BE IT RESOLVED, That the City Planning Commission of the City of Santa Cruz does hereby recommend to the City Council of the City of Santa Cruz, the adoption of the Seismic Safety and Safety Element as a proper amendment to the General Plan for the future development of the City of Santa Cruz, a copy of which is on file in the office of the City Clerk;

PASSED AND ADOPTED, This 27th day of May, 1976, by the following vote:

AYES: Commissioners - Bowden, Darrow, Leonard, DeWitt, Seivertson; Chairman Thompson

NOES: Commissioners - None

ABSENT: Commissioners - Shaffer

APPROVED

Chairman

ATTEST John L. Lawrence

Secretary

RESOLUTION NO. NS-12,058

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF SANTA CRUZ AMENDING THE GENERAL PLAN BY ADOPTING A SEISMIC SAFETY AND SAFETY ELEMENT.

WHEREAS, by Resolution No. NS 7489, adopted on April 28, 1964, the City Council did adopt a General Plan for the City of Santa Cruz; and

WHEREAS, the State of California Planning Law provides for a Seismic Safety and Safety Element to the General Plan; and

WHEREAS, the Seismic Safety and Safety Element provides for seismic safety and flood, fire and geologic safety needs in the City of Santa Cruz; and

WHEREAS, the Santa Cruz City Planning Commission has reviewed the Seismic Safety and Safety Element as a proposed amendment to the General Plan; and

WHEREAS, after careful study, the Planning Commission approved and certified to the City Council said Seismic Safety and Safety Element as an amendment to the General Plan; and

WHEREAS, the City Council considered all of the recommendations of the Planning Commission, and the evidence presented to the Council at its hearing thereon, and now finds and determines that the Seismic Safety and Safety Element as recommended by Planning Commission Resolution CPC-76-20, attached hereto and incorporated herein as Exhibit "A", constitutues a suitable amendment to the General Plan for the future development of the City of Santa Cruz;

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Santa Cruz as follows:

1. That the General Plan for the City of Santa Cruz as heretofore adopted by the City Council on April 28, 1964 by Resolution No. NS-7498, and as said General Plan has been subsequently amended, is hereby amended and there is hereby adopted as said

amendment, the Seismic Safety and Safety Element which is attached hereto marked Exhibit "A".

2. The said General Plan and all of the amendments thereof shall be the guide for future capital improvements and physical developments of the City of Santa Cruz, and for the adoption of precise plans, regulations and legislation for the administration of such General Plan.

PASSED AND ADOPTED this 13th day of July, 1976, by the following vote:

AYES: Councilmen - De Palma, Edler, Muhly, Melville, Di Girolamo, Ghio; Mayor Mahaney

NOES: Councilmen - None

ABSENT: Councilmen - None

APPROVED: Robert G. Mahaney
MAYOR

Attest: Angèle Mellon
City Clerk

California Government Code Section 65302(f) requires a Seismic Safety Element to be a part of all City and County General Plans. California Government Code Section 65302.1 requires a Safety Element to be a part of all City and County General Plans. The Council of Intergovernmental Relations was mandated to develop and adopt guidelines for the preparation and content of all the mandatory elements of the General Plan. In developing those guidelines, the Council recognized the strong relationship between the Seismic Safety Element and the Safety Element, and made permissible the preparation of these two elements simultaneously or the combination of the two elements into a single document. The City of Santa Cruz has opted to combine the two elements, due to the common purpose of both elements, that being to ensure adequate consideration for hazards in the planning process.

PREFACE

The City of Santa Cruz Seismic Safety and Safety Element was prepared first and foremost to establish a responsible policy basis for dealing with hazards in Santa Cruz. The Element also fulfills the State-mandated requirements for the preparation of a Seismic Safety Element and a Safety Element. Whereas, the focus of this 1976 version of the Element is primarily on natural hazards, it does not preclude the revision of the Element at a later date to include public safety hazards.

The adoption of this Element reflects a City policy statement dealing with Santa Cruz' approach to life and property safety. That approach is strongly influenced by the fact that with an established urban center, the development of safety policy is a case of working with real constraints (such as established land use patterns, buildings, and roads) and not a case of working with unlimited land use constraint possibilities. For this reason, this Element primarily focuses on structural safety and disaster preparedness rather than the more basic concern of whether or not to locate in hazard-prone areas. For the City of Santa Cruz, that decision was made hundreds of years ago.

This Element accurately points out that Santa Cruz is located in an area subject to many natural hazards including earthquakes, tsunamis, floods cliff retreats, and wildfires. However, to preface this Element by stating "Santa Cruz has been mistakenly established on the San Lorenzo river flood plain which is in a liquefaction area subject to tsunzmi inundation and, therefore, safety policy must now focus on disaster planning and structural safety" would not correctly reflect the tenor of this Element. It is true the emphasis is on preparedness for hazards but it is not an absolute truth that it was a mistake to locat the City in its current location.

The tenor of the Santa Cruz Seismic Safety and Safety Element is more correctly reflected by stating "Santa Cruz has been long established in a desired coastal area which is subject to natural hazards on a periodic basis. For the continued enjoyment of this area, it is imperative that its residents become, and remain, aware of the hazards that can affect them. It is also imperative that the public decision-making bodies establish responsible policies that will enable the citizens of Santa Cruz to safely and appropriately plan in accordance with the constraints of nature. For this reason, the focus of the Santa Cruz Seismic Safety and Safety Element is on policies designed to make the City better prepared for a natural hazard, and policies designed to make the structures safer in the event of an earthquake."

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CHAPTER I - BACKGROUND

A. Introduction

The land use planning process is an ongoing process reflecting the coordination of environmental, social, and economic concerns of Santa Cruz. Its purpose is to formulate policies and programs that will attain the needs and desires of the residents of the City. Seismic Safety and Safety Planning is a vital element in the process, without which, the attainment of our land use goals is subject to undue risk.

Safety Planning is designed to avoid or reduce loss of life, injury, and property damage resulting from hazards. Since hazards are measured in terms of potential losses, based on human activity, the degree of hazards can be evaluated and partially controlled by the extent and intensity of human activity in the hazard-prone area.

The Seismic Safety and Safety Element will attempt to define the hazards in Santa Cruz, evaluate their potential for loss and destruction, and present policies and programs for reducing the risk the hazards represent.

B. Purpose and Goal

The Seismic Safety and Safety Element is intended to help make our community safer—safer from hazards; safer for people. Whereas, such a goal is unattainable in its perfect state, action can be taken to strive for safety, thereby reducing the risk of a hazard affecting the lives of the people living in and visiting Santa Cruz. The accomplishment of such a reduction in risk is a two-step process:

a) Identify the problems (hazards); and
b) Suggest solutions (policies).

Identifying the problem is a two-step process:

a) Identify the hazards that threaten people and property; and
b) Identify conflict areas—hazard-prone areas occupied by people.

Suggesting solutions is a two-step process:

a) Formulate policies to help make safe both existing and future residents and visitors of Santa Cruz; and
b) Implement those policies.

The purpose of this element, then, is to ensure that the proper steps are taken to establish policies designed to reduce the risk from hazards. The goal is the attainment of such a reduction.

C. The Element's Relationship to the General Plan

The Seismic Safety and Safety Element is not intended to stand alone as a singular plan. Rather, it should be viewed as a major part of the General Plan. The land use policies of the General Plan are determined by environmental, social, and economic considerations in addition to the specific considerations for safety. Whereas, safety planning is important to the fulfillment of the needs and desires of the people of Santa Cruz and, whereas its policies should be considered throughout the land use planning process, its policies must be interwoven into the policies developed in the Land Use,

Circulation, Housing, Open Space and Conservation, Noise, Scenic Highways, and Historic Preservation Elements to the General Plan.

CHAPTER II - HAZARD IDENTIFICATION

A. Introduction

The identification of hazards that affect Santa Cruz is the first step in the safety planning process. It represents, possibly, the greatest challenge in planning because the consequences of inaccurate hazard identification would be the formulation of inadequate safety land use policies. The result might be unnecessary loss of life, injury, and property damage.

The natural hazards that have affected Santa Cruz in the past and those that may affect it in the future can be identified with a high degree of accuracy. Flooding, earthquakes, and cliff retreat have all touched the community within the past twenty-five years. Whereas, recent earthquakes and cliff retreat have been minimal in their hazardous effects on the City, flooding on the San Lorenzo River has caused considerable damage. In response to this hazard, levees were constructed in 1959.

The future extent of natural hazards in Santa Cruz is obviously an unknown factor. We do know, however, that in all probability the future will include the same kinds of hazards as have occurred in the past. Damage and loss of life may or may not be greater. Accurate hazard identification, however, is not simply an accounting of the past and warning for the future. It is an accounting of what the past tells us and, based on that information, an evaluation of the future. To properly evaluate the future, we must recognize and understand the risks involved with the current and proposed land uses.

B. Risk

The identification of hazard is closely allied with the recognition of risk. Hazard is defined as an unpredictable event that causes danger. Risk is the potential for such danger. The value in recognizing risk is that it provides a framework for evaluating the significance of a given hazard. If it is deemed that a hazard represents a high risk situation, measures can be taken to reduce risk to acceptable levels.

In safety planning, the determination of acceptable risk requires judgement based on weighing several factors. The factors include the nature of the hazard, the expected frequency of the hazard, the number of persons exposed to the hazard, and the community's willingness to be exposed to the hazard. Acceptable risk in safety planning is based solely on concerns for the community with emphasis on reducing injury and loss of life.

The broader planning process involves more than safety concerns. Acceptable risk is based upon a wider range of concerns including social, economic, and environmental as well as safety concerns. If it were not for the reality that life involves more than just staying alive, these additional concerns would not play a role in the determination of acceptable risk. But, because they do, acceptable risk, based solely on safety concerns, becomes unacceptably low; just as unacceptable as an excessively high level of risk. The overall result is a higher level of acceptable risk than that which is based solely on safety concerns. For example, to prevent further development in downtown Santa Cruz due to its susceptibility to liquefaction and to encourage its relocation to the East Side would reflect an acceptable level of risk based solely on safety concerns. However, when the social and economic desires of the City to enhance and maintain the Pacific Garden Mall come into play, a

higher risk situation becomes acceptable. Consequently, when mitigation costs for safety hazards exceed what the public is willing to pay; or when existing land uses reflect a consciously accepted high risk situation, acceptable risk may well be higher than if based solely on safety concerns.

The hazards that affect Santa Cruz and their associated risk will be identified in the following hazard identification sections of this document. Risk-reducing measures will be recommended for each high-risk situation identifed.

Acceptable levels of risk based on safety concerns will be identified in this Element and will ultimately be reflected in the Land Use Element of the General Plan, at which point all land use concerns will be weighed and choices will be made.

C. Discussion of Hazards

1. Earthquake Hazards

The City of Santa Cruz, like most of the Western United States, is in a region of high seismic activity and is, therefore, always in danger of a destructive earthquake. As is well known, earthquakes strike quickly, without apparent warning, and along with their secondary effects (landslides, tsunamis, liquefaction, etc.), can leave an aftermath of extensive damage, injury, and death.

The identification of earthquake hazards in Santa Cruz requires a description of the potentially active earthquake faults within the region and a description of the secondary effects of earthquake activity. The faults and their potential for inducing surface faulting, groundshaking, landslides, liquefaction, tsunamis, and seiches, contribute to the designation of Santa Cruz County as a high seismic activity area.

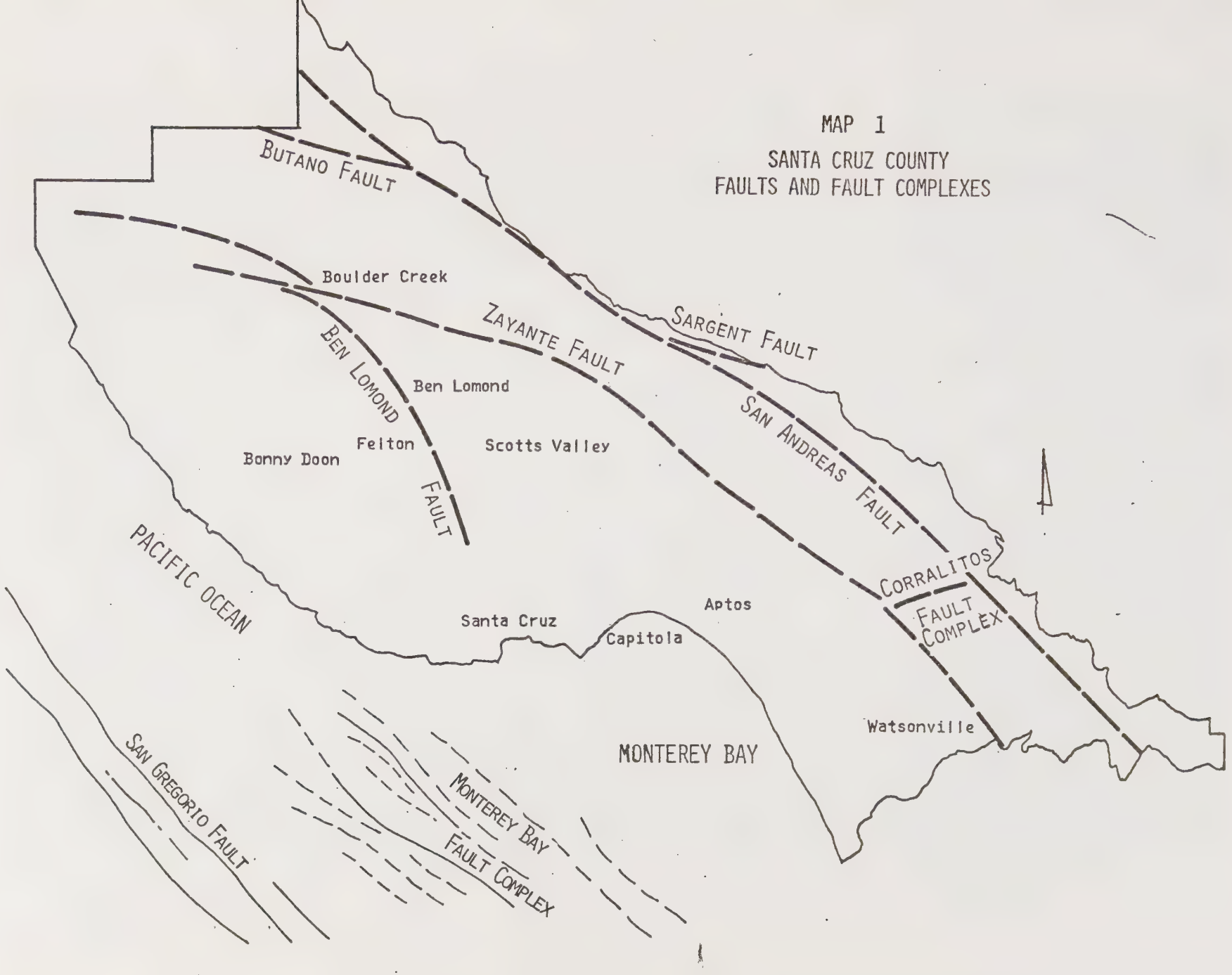
A description of the faults in Santa Cruz County includes an indication of each fault's maximum magnitude, recurrence interval and its potential for surface rupture. The fault locations are mapped on page 5 (Map 1).

The description of the secondary effects of earthquake activity, will include discussion of each effect and the mapping of its influence in the City.

The identification and description of the foregoing earthquake hazards are based solely upon the information contained in the Santa Cruz County Seismic Safety Element. The County's element, in turn, is based upon a seismic study of the County undertaken by the United States Geological Survey for the purpose of providing basic seismic data necessary to the preparation of seismic safety elements in Santa Cruz County. The U.S.G.S. study provides the basis for a coordinated approach to seismic safety planning within the County. It was partially funded by the City of Santa Cruz.

a. Earthquake Faults and Fault Zones in Santa Cruz County: There are seven major fault zones within the County (see Map 1). Of these, the San Andreas is the most infamous. The Fault represents the boundary between two large plates—the Pacific, comprised of the northern Pacific Ocean and west coast of California; and the North American, containing the rest of the continent and the western Atlantic Ocean. Thus, it is one of the world's major faults.

The San Andreas Fault system actually encompasses most of the Fault zones in the County, albeit the San Andreas is the dominant feature.


MAP 1
SANTA CRUZ COUNTY
FAULTS AND FAULT COMPLEXES
BUTANO FAULT
Boulder Creek
ZAYANTE FAULT
SARGENT FAULT
BEN LOMOND FAULT
Ben Lomond
Felton
Scotts Valley
Bonny Doon
SAN ANDREAS FAULT
CORRALITOS FAULT COMPLEX
PACIFIC OCEAN
Santa Cruz
Capitola
Aptos
Watsonville
MONTEREY BAY
SAN GREGORIO FAULT
MONTEREY BAY FAULT COMPLEX

Movement is in a right-lateral direction such that the California coast is, in essence, moving to the northwest. Activity varies along different segments of the fault, and very little movement has been recorded from Santa Cruz county northward since the destructive 1906 San Francisco earthquake with its epicenter in Marin County. However, the segment south of Pajaro Gap, in the Hollister area, undergoes continuous creeping movement. While either area has the potential for a major earthquake at any time, the more inactive segment may pose a greater threat since energy is building there rather than being gradually dissipated. The maximum predicted earthquake magnitude on the San Andreas is 8.5 on the Richter Scale (see insert below), with a recurrence interval of 100-1,000 years, although the shorter estimate seems more probable for another 1906-type earthquake. A 50-100 year interval has been predicted for a major earthquake of magnitude 7.0. Additionally, the potential for surface rupture on the San Andreas is high.

Richter Scale

Developed by Charles Richter, the Richter Scale of earthquake magnitude is based on the maximum amplitude, recorded on a seismogram from a specified standard-type instrument, situated 62 miles from the epicenter. The energy released is assessed on a logarithmic scale, with each upward step in magnitude representing a 32-fold increase in released energy. Earthquakes are classified according to their magnitude as great, greater than 7.7; major, 7.0-7.7; and moderate, 6.0-6.9. For example, the 1906 San Francisco earthquake of magnitude 8.3 was considered a great earthquake; and the 1971 San Fernando earthquake, magnitude 6.5, was moderate.

Just offshore lies the San Gregorio Fault. A major branch of the San Andreas, it is currently active and capable of generating destructive earthquakes of magnitude 7.2-7.9, and up to 8.5 if significant vertical movement occurs. The potential for surface rupture is moderate to high, as is the threat of tsunamis. The Fault is probably analogous to the Hayward Fault which has a recurrence interval of 10-100 years for a magnitude 6.0-7.0 earthquake.

The Zayante Fault, which parallels the San Andreas to the southwest, is potentially active. It has exhibited both horizontal and vertical movement, and evidence seems to indicate recent activity. The Zayante is capable of generating a major earthquake of magnitude 7.4 although the recurrence interval is essentially unknown. Estimates range from as low as 100 to a maximum of 10,000 years. A moderate potential for surface rupture exists along portions of the Fault although there is still insufficient data on other segments.

Geomorphic and stratigraphic evidence indicates that a diffuse group of splinter faults, known as the Corralitos Fault Complex, acts as a possible connection between the Zayante and San Andreas Faults. Its existence and nature have not been firmly established even though it is considered potentially active. It has a predicted maximum magnitude of 6.9, assuming it is the extension of the southeast segment of Zayante Fault. The recurrence interval would, therefore, be similar to that of the Zayante. There is a moderate potential for surface

rupture on the most confidently established segments of the Fault; the others require additional information.

The Butano and Sargent Faults branch off the San Andreas near Skyland Ridge, to the northwest and southeast, respectively, and represent another potentially active component of the San Andreas system. Several epicenters are concentrated in the area between the Butano and Zayante Faults, but it is not clear which fault they have been produced by. There is a moderate potential for surface rupture along some portions of the Butano while others require additional data as does the Sargent. Because of their geometric relationship to the San Andreas, they may have similar histories and seismic potential. The estimated maximum earthquake magnitude for the Butano is 6.4, although the recurrence interval is unknown. It is, no doubt, similar to the Corralitos-Zayante due to their correlative association with the San Andreas.

The Ben Lomond Fault has an insignficant number of recorded epicenters and may possibly be inactive. The estimated maximum magnitude is 5.5 with an unknown recurrence interval.

Finally, worth noting, is the Monterey Bay Complex. This group of faults lies just offshore, is potentially active, and is capable of generating a damaging tsunami. Further study of its onshore extensions is necessary to determine, with certainty, its maximum magnitude earthquake. The estimated maximum magnitude is 6.5 with an unknown recurrence interval (possibly less than 100 years).

b. Surface Faulting: Faults are the fractures along which two large crustal plates slip. Movement along faults may occur either with or without actual breakage of the earth's surface. A fault is not one continuous line but rather a series of traces which splinter off in a zone tens to thousands of feet in width. Although surface rupture may occur anywhere within a fault zone, it will generally occur along a line of previous fracture.

Within a fault zone, there is potential for earth fracture and surface displacement. These are the most conspicuous manifestations of fault movement. Structures built in a fault zone are subject to severe structural damage. Such structural damage can usually be prevented by locating buildings off lines of previous ruptures.

Fault movement is usually the result of a sudden, violent release of energy, which has built up over a long period of time. As a break occurs, this energy is released in the form of vibratory waves. The P-wave arrives first as a sharp, blast-like jolt followed by S-waves which exhibit a rolling or swaying motion. The latter produce the violent ground shaking which is responsible for most of the injury, death, and property damage during an earthquake. Ground shaking is discussed later in this Chapter. Movement may also occur as a slow, gradual creep. This gradual dissipation of energy is damaging to both the ground and structures, but it occurs over a long span of time and may go undetected for a while. It is theorized that this steady creep continually releases tension, thereby lowering the potential for a major earthquake.

In addition to activity and type of movement, faults can also be classified according to direction or sense of movement (Figure 1, page 9). Movement may be vertical, horizontal, or a combination of the two.

The potential for surface faulting in the City of Santa Cruz appears to be non-existent. Of the seven faults and fault systems already identified, none are located within the City limits.

The only known possible threat of surface faulting in the City would be from the Ben Lomond Fault. It roughly parallels the San Lorenzo River, north of Boulder Creek,and runs southeast to Paradise Park, just north of the City limits. Due to its connection to the Zayante Fault, and the fact that it strikes directly toward the City, further study is warranted.

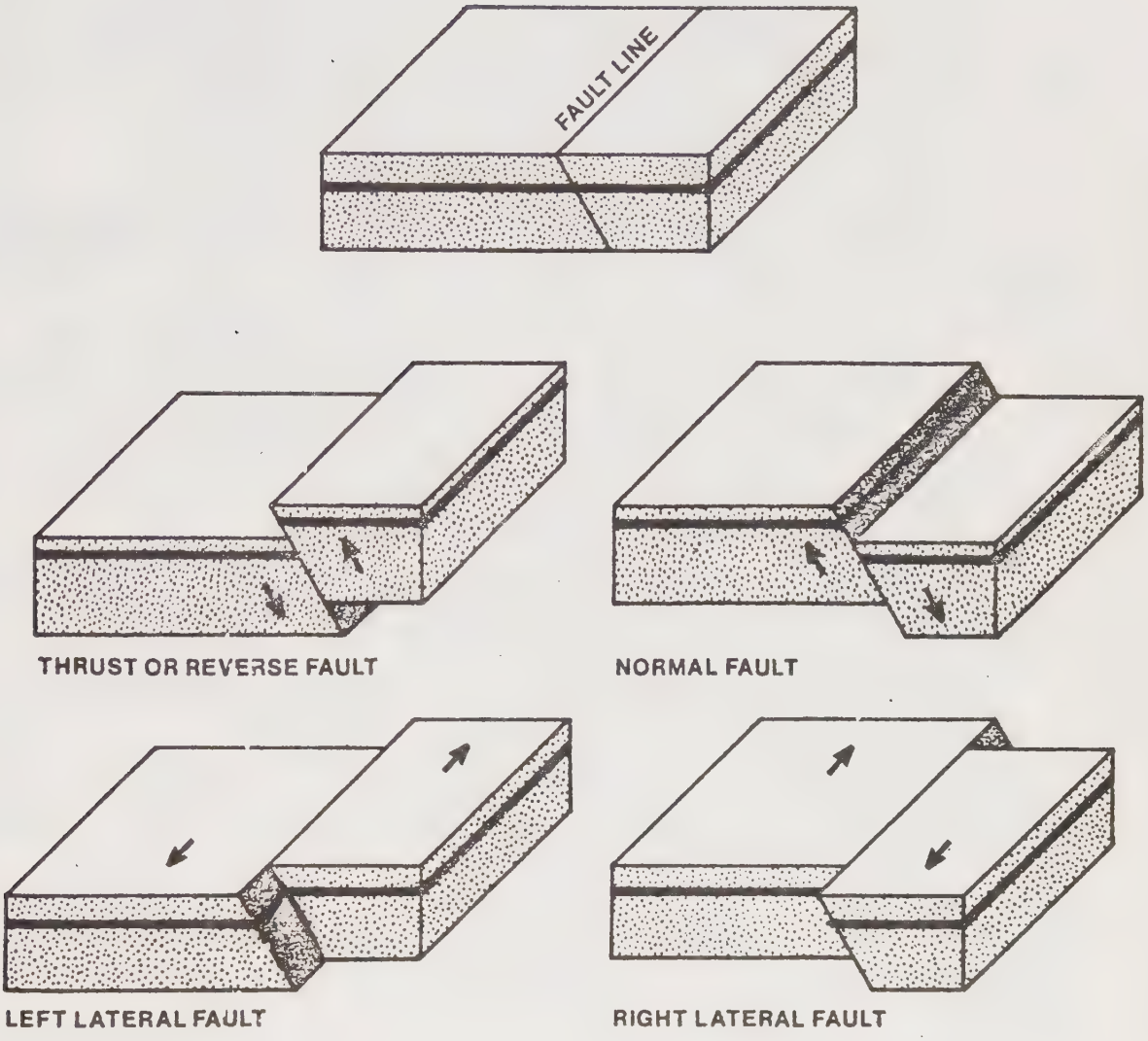
The fact that surface faulting is apparently not a threat to the City of Santa Cruz should not be interpreted to mean Santa Cruz is free of seismic activity. The City's proximity to seven faults and fault systems, not least of which is the San Andreas Fault, represents other earthquake-related hazards, all of which are discussed on the following pages.

c. Ground Shaking: Historically, ground shaking has been the primary cause of damage and injury during earthquakes. However, it is one of the most difficult of all the seismic hazards to predict and quantify.

In a very gross sense, the severity of ground shaking appears to be related to the firmness of the ground. Areas underlaid by thick, saturated, unconsolidated sediments will experience greater shaking motion than areas underlain by firm bedrock. Additional factors in the assessment of shaking severity and associated damage include magnitude of the earthquake, distance from the epicenter, structural integrity of the building, relationship between the fundamental periods of the building and the ground on which it sits. The fundamental period is the time necessary to complete a vibration cycle. The fundamental period of the building is controlled by its height while the fundamental period of the ground is controlled by local geologic/hydrologic conditions. Past experience indicates that when the periodicity of a structure and the ground it is sitting on coincide, an amplified effect will result and damage is more likely to occur.

Although Santa Cruz is in a high seismic risk zone, the effects of ground shaking on the City of Santa Cruz have been relatively mild. Of the 22 recorded earthquakes since 1865 noted in the Santa Cruz County Seismic Element, none have caused extensive damage to Santa Cruz (see Appendix A). Mid and south Santa Cruz County have demonstrated a higher propensity for earthquake activity than has the City of Santa Cruz. This may indicate a greater threat to the City of Santa Cruz from a major earhquake due to the fact that energy may be building rather than being gradually dissipated.

FIGURE 1
direction of fault movement



The entire County is subject to ground shaking which, in turn, is related to the epicenter of the individual earthquakes. For this reason, there are no specific areas that can be mapped within the City of Santa Cruz that are either not subject to, or more susceptible to ground shaking. The entire City is subject to severe ground shaking.

d. Landslides: A landslide is defined as a rapid downward movement of rock, earth or artificial fill on a slope.

Factors that can cause landsliding include the inherent properties of the slope-forming materials such as rock strength and orientation of planar elements, as well as erosion, weathering, high rainfall, steep slopes, seismic shaking, and human activities. Man contributes to the instability of slopes through removal of vegetation, improper grading, and addition of water to the ground.

Although landsliding is not usually attributed to a single cause, earthquakes frequently trigger slides on already unstable slopes. Because the movement of slides during an earthquake is extremely rapid, a greater potential for loss of life exists.

A widespread landslide condition is found in Santa Cruz County. This is typical of the entire Coastal Range of California. Landslides within the County appear to be limited to those areas of over 15% slope with the intensity of landslides in the County greatest in its northern and eastern sections where the land is mountainous. Landslides are considerably less frequent in the gently sloping southern and western portions of the County.

Several of the large slides, as well as numerous smaller ones, are found along the San Andreas Fault zone, indicating a strong correlation between seismic activity and large-scale landsliding.

The City of Santa Cruz is not as susceptible to landslides as is the County as a whole. Two key factors lend themselves to this situation:

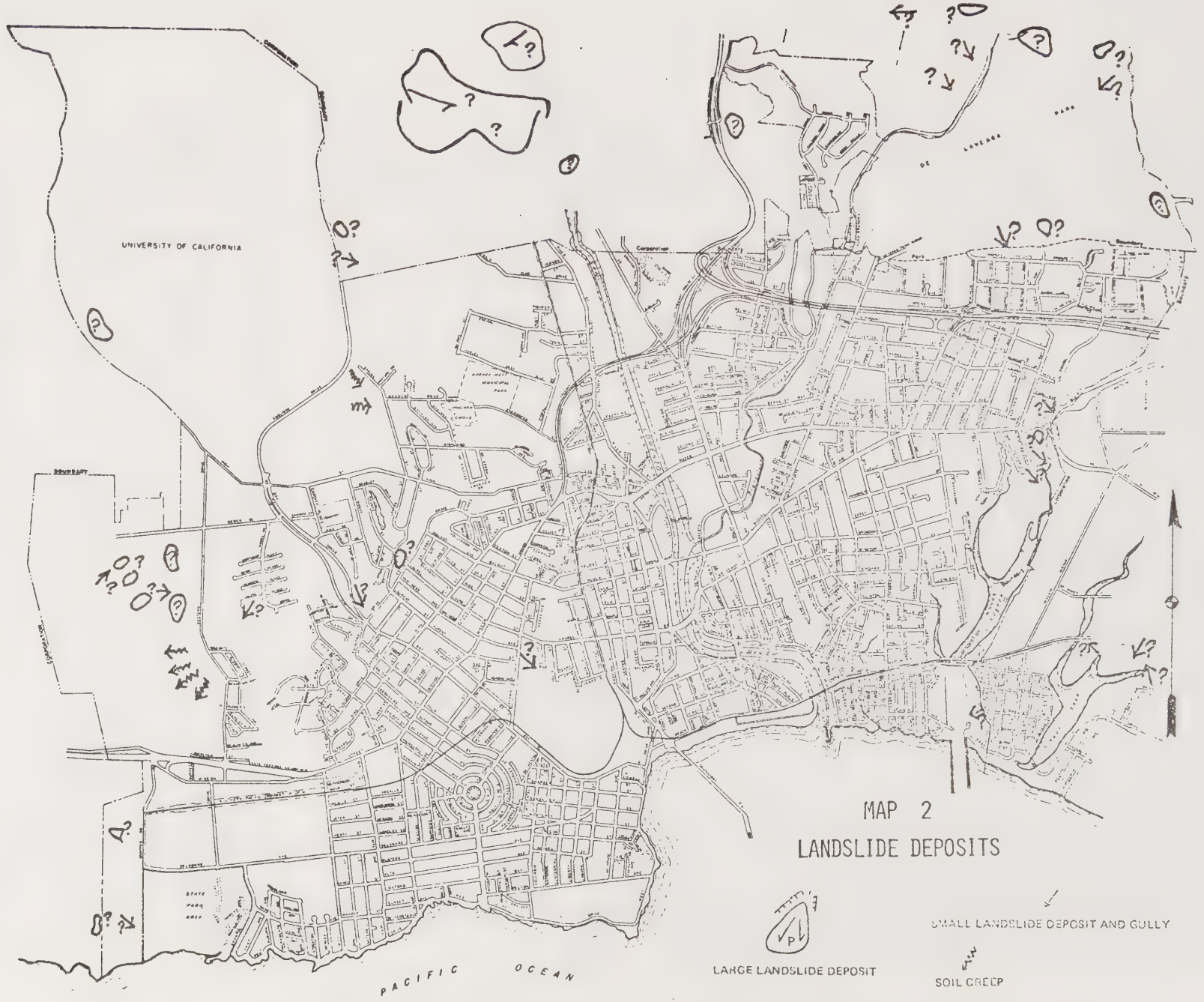
1) Santa Cruz is in the gently sloping western portion of the county identified above as being least prone to landslides; and
2) Santa Cruz is not crossed by fault zones and their accompanying high correlation to large-scale landsliding.

Landslide deposits located in the City occur primarily on the western side in and around Moore Creek Canyon. Landslide deposits are also found in the upper reaches of Woods Lagoon and DeLaveaga Park, as well as isolated locations throughout the City.

The areas prone to landslides and soil creep are indicated on Map 2, page 11. The arrows indicate the direction of small landslide areas, 50-500 feet maximum dimensions. Zigzag arrows represent areas affected by soil creep or gradual downhill movement of soil and loose rock material. Question marks accompany nearly all symbols as the data was obtained from photo interpretation and further field checking is necessary for definite findings.

Beyond City limits, but of critical concern, are the landslide areas that cross Highway 9, and those that are directed toward the Loch Lomond Reservoir.

e. Liquefaction: Liquefaction is defined as the transformation of


UNIVERSITY OF CALIFORNIA
PACIFIC OCEAN
MAP 2
LANDSLIDE DEPOSITS
LARGE LANDSLIDE DEPOSIT
SMALL LANDSLIDE DEPOSIT AND GULLY
SOIL CREEP

a granular material from a solid to a liquefied state as a result of increased pore water pressures. It is a common result of earthquake in areas underlaid by saturated unconsolidated deposits. During seismic shaking, the granular material tends to compact which causes an increase in the pore water pressure. When this pressure exceeds the shear resistance of the material, the material loses its shear strength and becomes liquified.

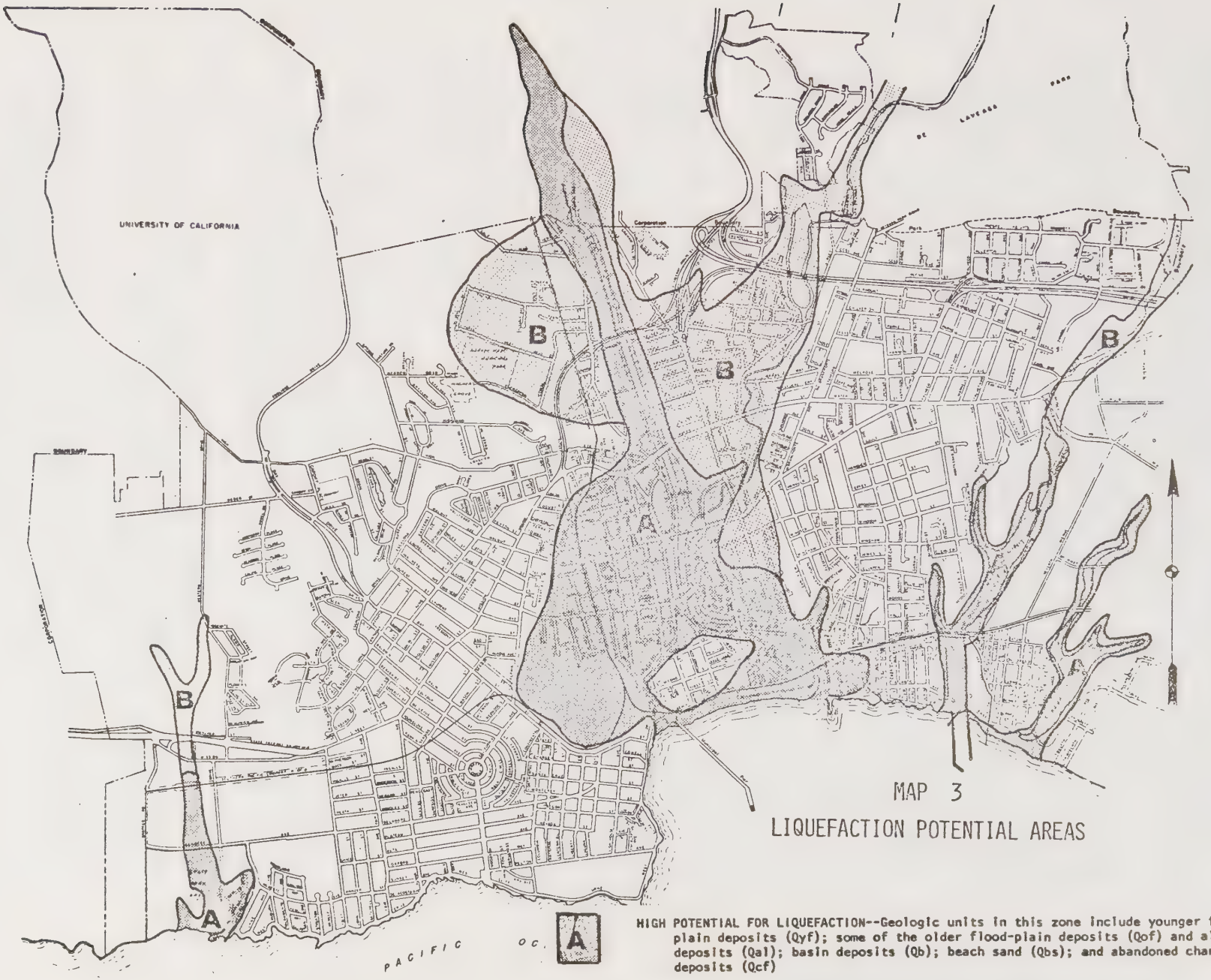
Liquefaction commonly, but not always, leads to ground failure. Three types of ground failure are often associated with liquefaction; these include flow landslides, lateral spreading landslides, and quick-condition failures. Quick-condition failures occur on level ground while lateral spreading landslides and flow landslides occur on nearly horizontal to steep slopes. References to lateral spreading landslides are often found in the literature under different terms such as earth lurches and land spreading.

Potential for liquefaction is divided into four zones based on the USGS Seismic Study of Santa Cruz County. Zone A contains geologic units with a high potential for liquefaction; Zone B, a moderately high potential; Zone C, a moderately low potential; and Zone D, a low potential. The area adjacent to the San Lorenzo River in the City of Santa Cruz is within a zone of high potential, as is Neary's Lagoon and the Yacht Harbor. Moderately high potential in Santa Cruz is found in areas adjacent to Arana Gulch, Branciforte Creek, and Harvey West. Zones A & B present the greatest threat to Santa Cruz; therefore, mapping of liquefaction hazard areas is limited to Zones A & B (see Map 3, page 13).

It must be emphasized that the mapping of the zones show only where a potential for liquefaction exists, and not where liquefaction and associated ground failures will occur. It is known, however, that during the 1906 earthquake, ground failures resulting from liquefaction occurred along the San Lorenzo River. The lack of damage associated with these failures can be attributed to the undeveloped nature of the area at that time. Should an earthquake of similar magnitude occur today, tremendous damage could result from liquefaction-induced failures, not only to buildings, but to utility and communication lines, roads, bridges and overpasses, and other vital facilities.

f. Tsunamis: Tsunamis are large oceanic waves, often incorrectly referred to as tidal waves, which are caused by submarine volcanic eruptions or landslides, or vertical sea floor faulting. They occur as a series of long period, successional waves which travel at speeds up to 450 MPH, and are capable of massive destruction. The velocity of propogation varies with water depth at the generation site, and may be barely perceptible out at sea, where distance from trough to crest may be only a few feet. But as they move into shallow water, the wave height increases as the velocity decreases. Withdrawal of the sea frequently precedes the arrival of a tsunami, but this is not always the case.

Tsunamis affecting this area would probably be generated in South America or Alaska, although it is possible for local waves to be produced by faulting or off-shore slides in the Monterey Canyon.



MAP 3

LIQUEFACTION POTENTIAL AREAS

A — HIGH POTENTIAL FOR LIQUEFACTION--Geologic units in this zone include younger flood-plain deposits (Qyf); some of the older flood-plain deposits (Qof) and alluvial deposits (Qal); basin deposits (Qb); beach sand (Qbs); and abandoned channel fill deposits (Qcf)

B — MODERATELY HIGH POTENTIAL FOR LIQUEFACTION--Geologic units in this zone include some of the older flood-plain (Qof) and alluvial (Qal) deposits; dune sand (Qds); colluvium (Qc); and alluvial fan deposits (Qf)

Tsunamis cannot be prevented, but fortunately, the National Oceanic and Atmospheric Administration operates a reasonably effective warning system. Several hours notice can allow evacuation of threatened areas, preventing injuries and loss of life.

Only two tsunamis have had a notable effect on the Santa Cruz coast. On April 1, 1946, a great tsunami was generated by a moderate earthquake near the Aleutian Trench. Two successive waves (approximately 1½ hours apart) rose to a height of 12 feet and caused one fatality.

Another great seismic wave was generated by subsea faulting during the 1964 Alaskan earthquake. Santa Cruz experienced only a gradual rise in sea level and then a dramatic subsidence. The Yacht Harbor drained, and it was reported that one could walk two-thirds of the way out under the Capitola Wharf without getting wet. This same wave caused $11,000,000 damage at Crescent City, and eleven lives were lost. Other tsunami warnings have occurred, but few resulted in even high surf.

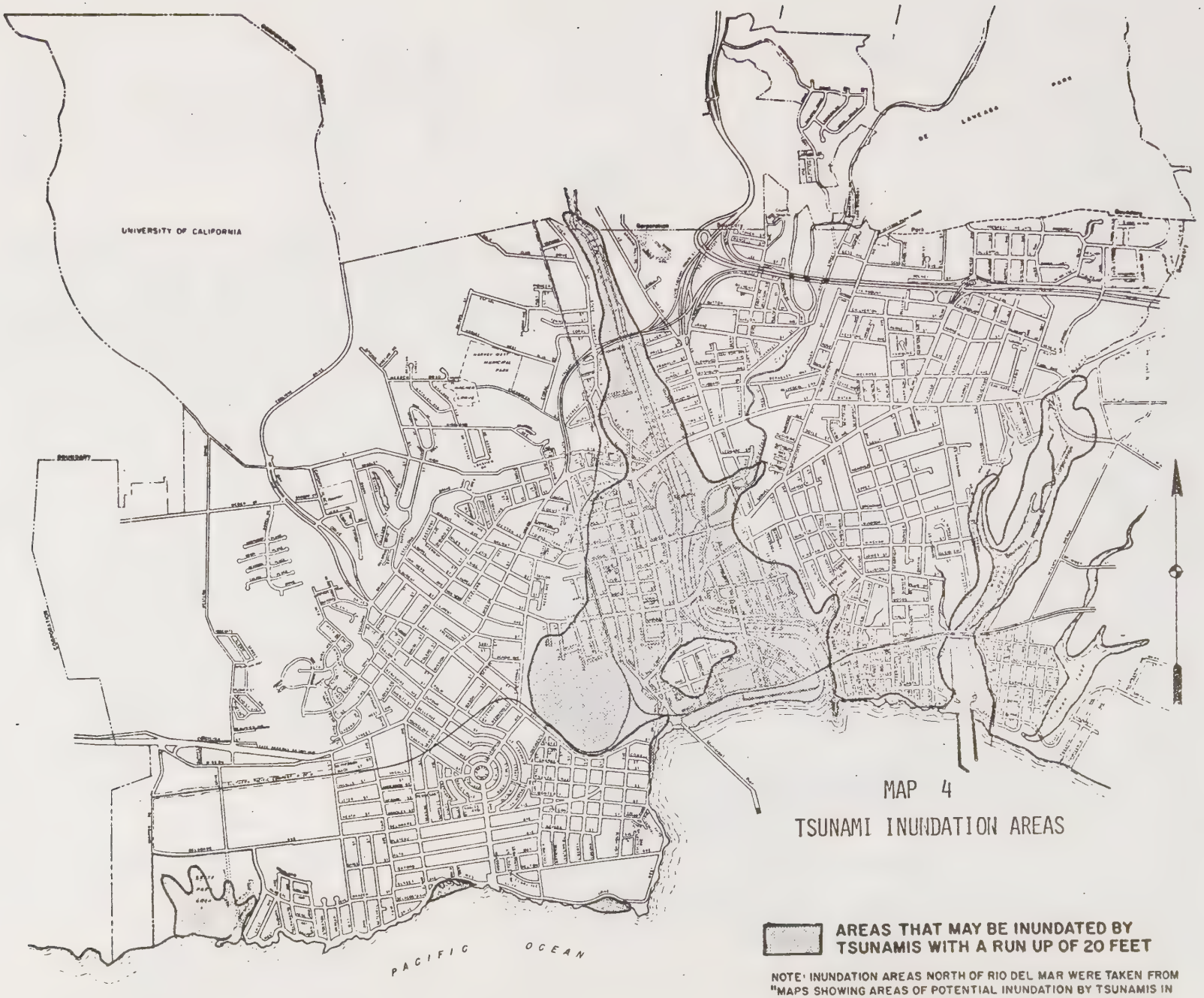
The City of Santa Cruz is susceptible to tsunami inundation primarily in the downtown area where the lowest elevations in the City occur. The potential tsunami inundation area in Santa Cruz is illustrated on Map 4, page 15.

g. Seiches: Seiches are large waves that occur in confined bodies of water like lakes, reservoirs or bays. Usually caused by winds, currents, or tides, they may also be generated by seismic shaking, lake bottom movement or displacement, or by landslides into the water. This phenomenon is likened to the sloshing of water in a bowl when it is shaken or jarred. Though the waves created are low in amplitude (less than one foot), in areas where water is constricted, run-up may be as much as 20-30 feet. Thus, the primary effect is on developments in close proximity to the shoreline, unless dam failure occurs. The oscillating movement can cause overtopping or actual dam breakage, resulting in inundation of downstream development.

In the City of Santa Cruz, the Bay Street Reservoir and the Yacht Harbor are the principal bodies of water subject to seiches. The Bay Street Reservoir now has a roof over it, as of January 1976, thereby lessening the chance of sloshing and spillage into areas immediately around it. Should seiches result in failure of the Bay Street Reservoir, a portion of the residential and commercial areas on the west side of Santa Cruz would be partially inundated (see Map 5, page 16).

Seiches in the Yacht Harbor represents a threat primarily to the boats and docking facilities within the Harbor. The majority of the developed areas around the harbor are at higher elevations and are not subject to damage from seiches.

The greatest threat to Santa Cruz resulting from seiches is potential dam failure of Loch Lomond (Newell Creek Dam). Should Newell Creek Dam fail as a result of seiches caused either by an earthquake or by landslides into the reservoir, most of downtown Santa Cruz would be inundated (see Map 5, page 15). It should be

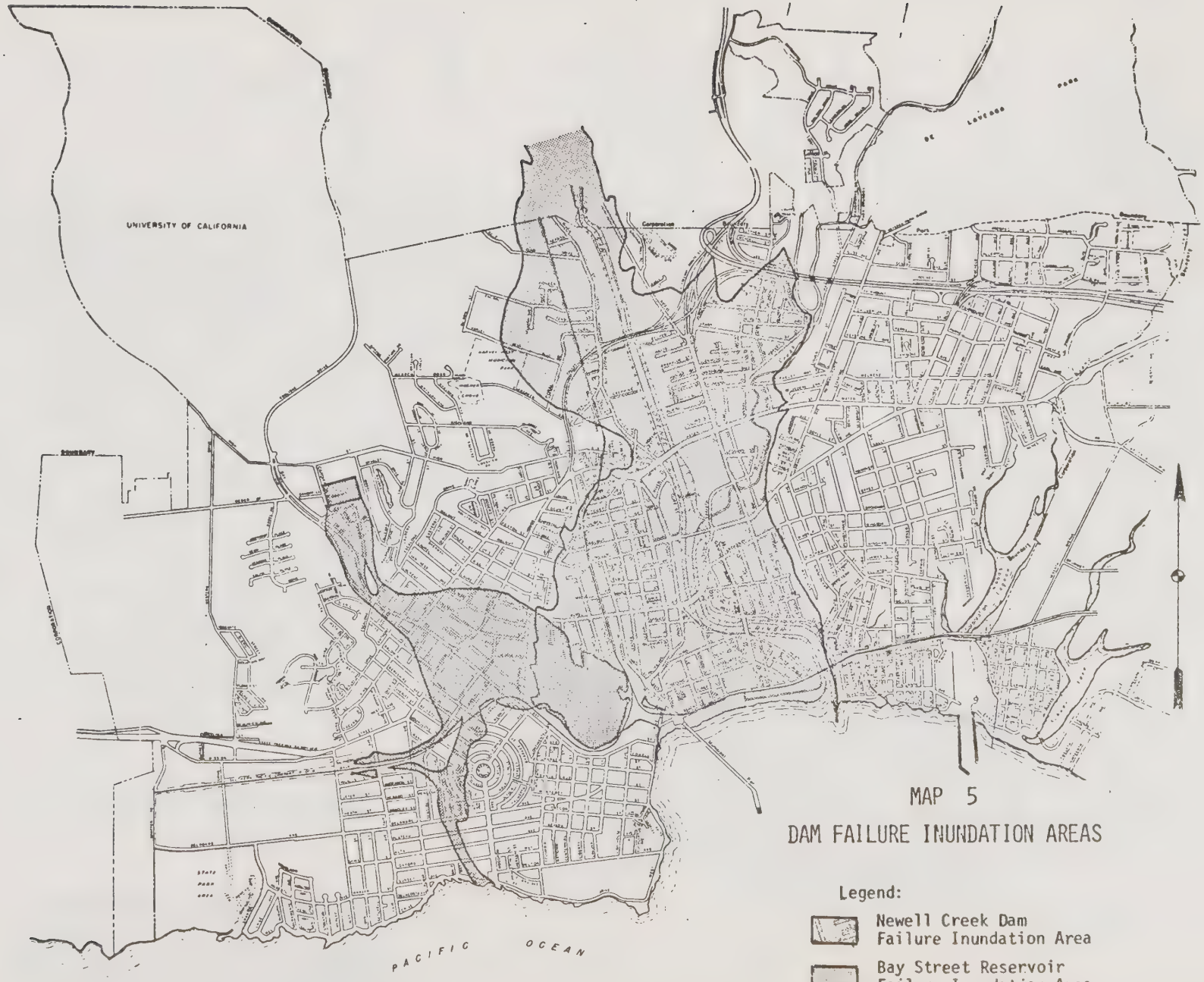


MAP 4

TSUNAMI INUNDATION AREAS

AREAS THAT MAY BE INUNDATED BY TSUNAMIS WITH A RUN UP OF 20 FEET

NOTE: INUNDATION AREAS NORTH OF RIO DEL MAR WERE TAKEN FROM "MAPS SHOWING AREAS OF POTENTIAL INUNDATION BY TSUNAMIS IN THE SAN FRANCISCO BAY REGION, CALIF. BY RITTER AND DUPRE. THE SAME METHOD USED BY RITTER AND DUPRE WAS EMPLOYED IN DETERMINING INUNDATION AREAS SOUTH OF RIO DEL MAR.



MAP 5

DAM FAILURE INUNDATION AREAS

Legend:

- Newell Creek Dam Failure Inundation Area
- Bay Street Reservoir Failure Inundation Area
- Area subject to both Newell Creek Dam and Bay Street Reservoir Failure

pointed out, however, that this is an extremely unlikely occurrence due to the fact that Newell Creek Dam (as well as Bay Street Reservoir) is monitored monthly for hydrology deviation, and semi-annually for bending, twisting and uplifting, in accordance with California Division of Safety of Dams requirements.

2. Cliff Retreat Hazard

Cliff retreat is the erosion of coastal headlands resulting from the continuous and forceful actions of waves and tides.

The moon and, to a lesser extent, the sun create ocean tides by gravitational forces. These forces, and the fact that the sun, the moon, and the earth are always in motion with relation to each other, cause waters of ocean basins to be in motion. These tidal motions of water masses are a form of very long period wave motion, resulting in a rise and fall of the water surface. Such a rise and fall wears away the headlands resulting in varying degrees of cliff retreat.

The familiar waves of the ocean are wind waves generated by winds blowing over water. They may vary in size from ripples to large ocean waves as high as 100 feet. Wind waves cause most of the damage to the ocean coasts and are the major force in cliff retreat. Another type of wave, the tsunami, has been discussed in a previous section.

Current surveys and past aerial photos indicate that, in Santa Cruz, the cliff retreat varies from three to four inches per year to much slower rates. It varies in rate due to wave action as well as geologic formation.

In areas where wave action contacts Santa Cruz mudstone formations, there exists a low potential for cliff erosion; and where purisma formation is in contact with wave action, there exists a moderate potential. Both situations exist along West Cliff Drive from Natural Bridges State Park to the Bay side of point Santa Cruz (see Map 6, page 19).

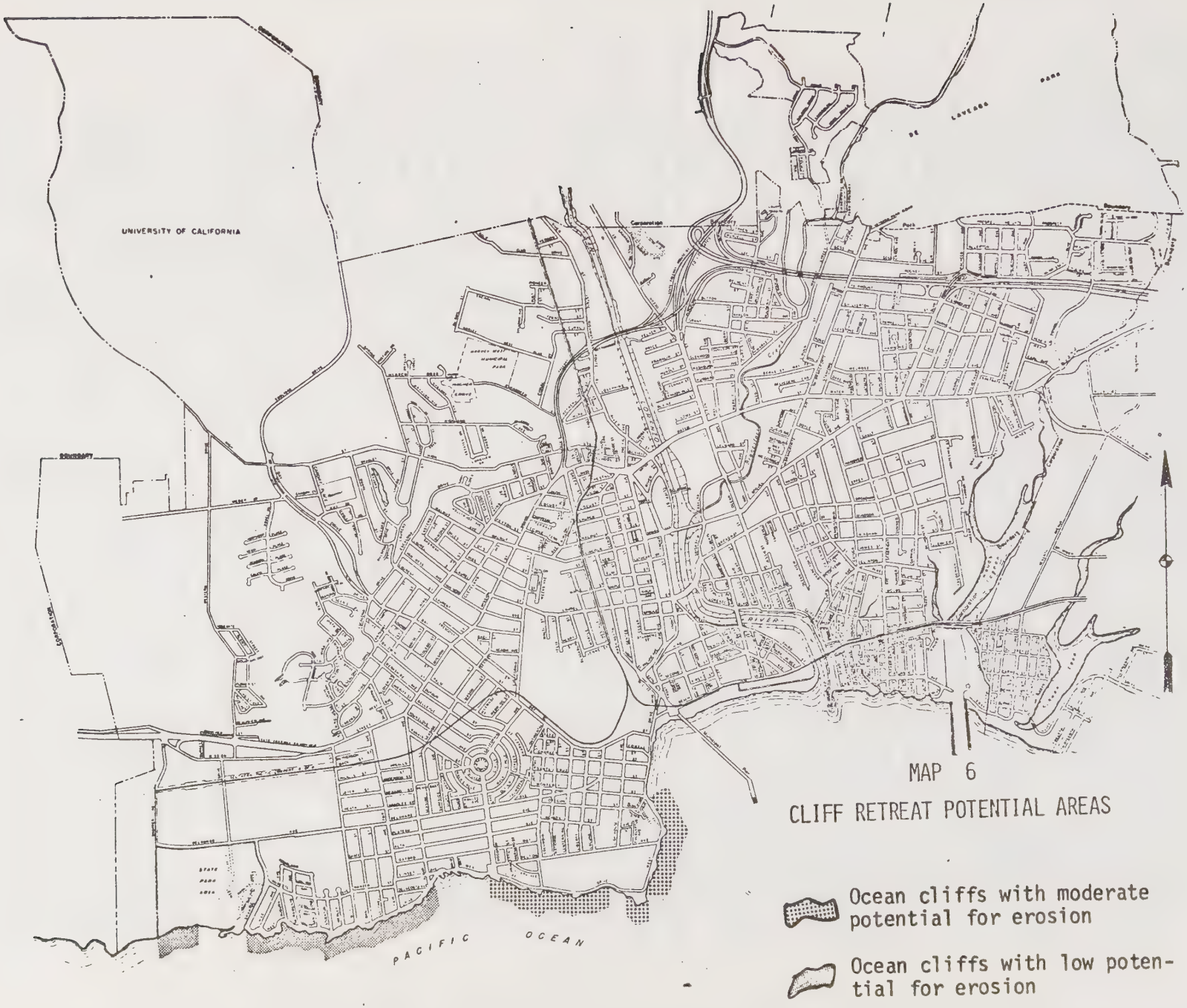
Where beaches exist along the City of Santa Cruz Bay and Ocean frontage, cliff retreat is insignificant, if not non-existent.

3. Flooding Hazard

In the pure sense of the word, flooding is any natural body of water that exceeds its natural banks. Such occurrences have historically been a benefit to agricultural soil, wildlife and the general ecological balance. Flooding is also viewed as a natural hazard. Such is the case when flooding is defined as any flow of water that threatens life and damages personal property. It is this sense of the word that is addressed in safety planning.

Floods are primarily due to excessive surface runoff. In Santa Cruz, they can result from an intense rainfall, the melting of snow combined with rain, or a failure of flood control or water supply structures (levees, dams, or reservoirs). Flooding also results from tsunamis, previously covered under earthquake hazards.

The frequency of natural flooding is related to the frequency and return period of major rainstorms. Rivers were overtopped in accordance with this natural frequency long before human activity began to center around the river. When prolonged rainfall exceeds the water storage capacity of the watershed, the excess must be passed downstream. Human activities can increase flood damage and flood protection measures can reduce it; but people have little influence over the excessive rainfall that causes major floods. Therefore, we cannot prevent major floods, rather we devise methods and policies to protect ourselves and our property from them.



MAP 6

CLIFF RETREAT POTENTIAL AREAS

Ocean cliffs with moderate potential for erosion

Ocean cliffs with low potential for erosion

Flooding in Santa Cruz has occurred primarily along the San Lorenzo River. Whereas, few records exist of past floods in the San Lorenzo Basin, it is known that damaging floods occurred in 1940, 1955 and 1958. The most damaging flood occurred in 1955, when total estimated flood damage reached $7,500,000 within the City limits of Santa Cruz. As a result, a U.S.Army Corps of Engineer Flood Control project comprising levees, a floodwall, and channel work was completed in 1959. The flood control measures are designed to protect Santa Cruz from a flood caused by a storm with a return period in excess of 100 years. These measures have substantially reduced the risk of flood hazard in the San Lorenzo River flood plain and development consistent with the reduced risk has occurred.

It should be pointed out that an essential element to maintaining the reduced risk from flooding on the San Lorenzo River is an effective channel maintenance program. Aggradation of the river bottom results from the natural process of erosion and sedimentation, thereby reducing the capacity of the levee system to hold water. With a buildup of sediment in the river bottom comes a reduced effectiveness of the levee system, and a potential flood resulting from a storm representing less than a 100-year return period.

Channel maintenance, for safety purposes, is clearly in the interest of the citizens of Santa Cruz. The levee was constructed to carry a definite flow; a flow believed to represent one that rarely, if ever, would be exceeded. Any reduction in that flow would increase the risk of flooding downtown Santa Cruz. But channel maintenance also raises environmental issues; issues relative to the natural process of all rivers. Vegetation naturally grows in and around river channels; wildlife naturally inhabits such vegetation; sediments naturally build up in river channels; fish naturally spawn in river beds; and rivers naturally flood. All of these natural occurrences are in the scheme of maintaining a natural balance.

In the case of the San Lorenzo River, the natural balance was altered due to levee construction. It was for a specific purpose; that being to prevent further flooding. At that time a sacrifice was made to the natural balance in favor of safer development of downtown. And, as a result of that decision, development has increased in and around the levee with the belief that further flooding is extremely unlikely to occur. However, levee or not, the river continues to strive for a natural balance, which could include flooding if the river were allowed to flow without interference. In the case of the San Lorenzo River, flooding has been determined to be a portion of the natural balance that is unwanted in Santa Cruz; a portion as vital to the natural balance as vegetation, wildlife, or sedimentation. It is from this decision that conflict arises; a conflict between a concern for the natural balance and a concern for safety.

Appropriate safety policy (policy that strives for a reduction of risk to lives and property), dictates a need to maintain the water carrying capacity of the levees. And, whereas, by the nature of the work required, this reflects a conscious effort to continue the alteration of the natural balance, concern for the natural elements and the urban design qualities of the river should be reflected to the maximum extent possible in the channel maintenance program.

It should also be pointed out that, whereas it is extremely unlikely that a flood with a greater than 100+ year return period will occur, should it happen, damage would be catastrophic.

It should also be pointed out that, whereas it is extremely unlikely that a flood with a greater than 100+ year return period will occur, should it happen, damage would be catastrophic.

In addition to the San Lorenzo River, there are two additional areas in Santa Cruz subject to periodic flooding. They are Arana Gulch and the lower reaches of Moore Creek Canyon. Both have been identified as flood-prone areas in conjunction with the Natural Flood Insurance Program. Flooding is a definite hazard on the lower reaches of Moore Creek where only shallow stream channels are present, and in the lower portion of Arana Gulch north of the Santa Cruz Yacht Harbor. Arana Gulch is susceptible to tidal floods; floods in coastal areas caused by upland floods piling up against the high tides and incoming waves (see Map 7, page 22 for natural flood plains in Santa Cruz).

4. Wildfire Hazards

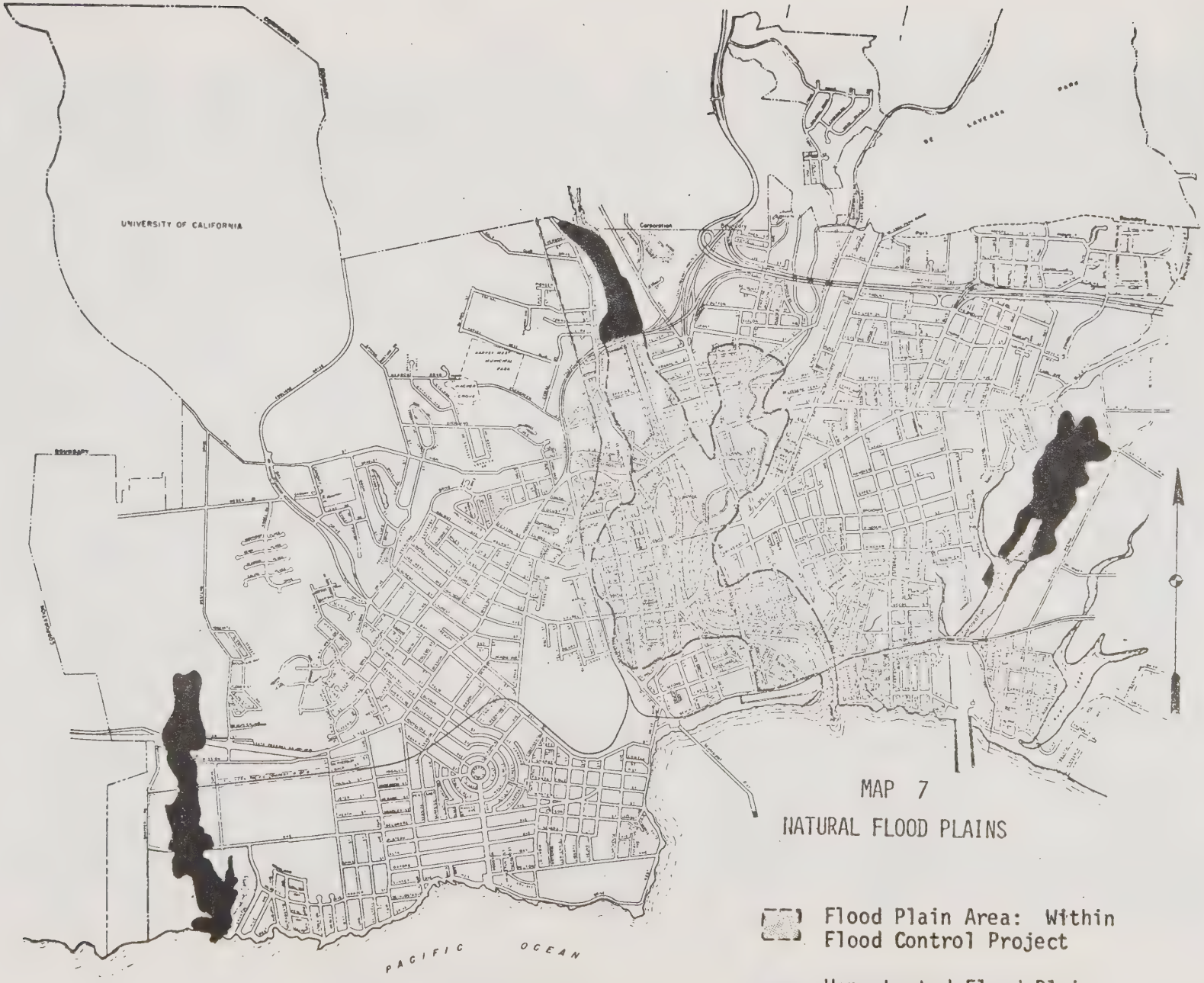
The potential for wildfires in the City of Santa Cruz relates to open space land use policy as well as safety policy. For this reason, fire hazards in Santa Cruz have been identified and discussed in the Open Space and Conservation Element to the General Plan, adopted in 1973. That discussion, determined by the Fire Department to be accurate in 1976, is represented here for continuity and completeness of the Seismic Safety Element.

Fire Hazard Areas: Destructive wildfires are a serious hazard in some portions of the City of Santa Cruz due to vegetation fuel build-ups, climatic, and topographic conditions. Areas shown on Map 8, page 23, are subject to dangerous fires which can become threats to present or future structures in the area. In large areas of the undeveloped western portion of Santa Cruz, there is a moderate fire hazard. Aside from the degree of severity, damage to wildlife habitats or structures can result in all fire hazard areas.

•Vegetation Type—Different vegetation types have varying propensities for fire conflagration. Some brush species, particularly chaparral, are extremely combustible because of highly volatile oils contained in leaves and stems. If, during the warm summer-fall drought season, these fuels are ignited, they will burn rapidly producing a very intense heat.

Adding to the problem are accumulations of dead limbs and vegetative debris. Before man's settlement, periodic lightning fires would burn off this material and thin out the brush stands. However, with the recent advent of fire suppression measures, this debris has accumulated adding tremendous quantities of volatile fuel to what is already available.

Grass, woodland, and forest vegetation do not create as great a hazard. Grass, although quick to ignite, burns at a low temperature, at ground level. Grass fires are relatively easy to suppress, providing the involved area is accessible to fire-fighting men and equipment. Likewise, woodlands are not as hazardous because of increased humidity, coolness and other modifying microclimatic conditions underneath the crown canopy. In mature stands, branches are high and not vulnerable to light, low fires. However, if an intense fire spreads to an adjacent woodland,



MAP 7

NATURAL FLOOD PLAINS

Flood Plain Area: Within Flood Control Project

Unprotected Flood Plain Areas.

MAP 8
FIRE HAZARD AREAS

a crown fire could develop and would be difficult to control. The objective of the City of Santa Cruz and the UCSC Fire Protection Programs to clear brush-type growth has lessened, to some degree, fire hazards in brush areas, woodland areas, and forest areas. The UCSC Fire Protection Program attempts to minimize damage to wildlife habitat by only removing dried limbs and vegetation debris, allowing the growing vegetation to remain as wildlife habitat. Complete clearing programs of brush, although a safety measure, may damage valuable wildlife areas. A listing of various plant species found in the Santa Cruz area and their fire potential is contained in the Open Space and Conservation Element.

•Slope—Steep slopes have an important effect on fire behavior, primarily because the flames are closer to the fuels. Generally, an increase in slope has the same effect as an increase in wind velocity in that both tend to increase the rate of fire spread. Steep slopes are also more inaccessible to fire-fighting men and equipment. Furthermore, in Santa Cruz, it has been found the highly flammable chaparral occurs more frequently on slopes greater than 30% where cattle grazing or other controls are more difficult. It appears that the simultaneous occurrence of flammable chaparral vegetation and slopes greater than 30% lead to a highly dangerous fire condition.

•Weather Conditions—Climatic conditions play an important role in fire formation and suppression. Late August and September are periods when local vegetation has received the minimum of moisture and are extremely dry. High winds are also common during this part of the year. The predominance of winds are from a southwesterly direction, which create conditions highly conductive to serious fires. Of particular danger are winds which sweep up the canyons on the western side of Santa Cruz. Here the combination of slope, dry vegetation, and canyons create extremely dangerous fire hazards along the immediate edge of the canyons. Any development in such areas may require minimum one-hundred-food setbacks from slope edges. The alternative is massive brush clearing which might prove economically unfeasible and produce serious erosion and other environmental problems.

D. Composite Hazard Identification

One of the most important functions of a map is to provide a basis for evaluating relative location. In safety planning, the relative location between people and hazard is of prime importance for evaluating potential safety problems. Thus far, the mapping of each potential hazard has provided an illustration of those areas susceptible to the individual hazard, and has aided in the understanding of each. Combining those maps into a composite map illustrates those specific areas within the City that are susceptible to one, two, three, or more natural hazards. Based on the composite map, areas of the City that necessitate the development and application of seismic safety and safety policy can be readily identified. On the following page, the composite map (Map 9) is presented. It will be used in Chapter III as a base map, upon which various City land uses will be overlapped, thereby illustrating conflict areas: hazard-prone areas occupied by people and their property.

MAP 9

COMPOSITE HAZARD MAP

Flood Hazard Areas

Geologic & Seismic Hazard Areas

Fire Hazard Areas

CHAPTER III - IMPACT IDENTIFICATION

A. Introduction

The natural hazards having potential to affect Santa Cruz have been defined. The hazard-prone areas have been mapped. They have been mapped individually and they have been mapped as a composite, illustrating areas in the City with the greatest potential for natural hazard. The development of the foregoing information has been the first step in identifying the seismic safety and safety problems in Santa Cruz.

The second and final step in safety problem identification is the determination of conflict areas—hazard-prone areas within the City that are occupied by people and property. The determination of conflict areas illustrates those areas of highest risk to life and property.

On the following pages, the composite hazard map is overlaid by land use, neighborhood designations, major transportation routes, utility facilities, emergency-related structures, and schools. Based on this illustration technique, potential impacts to people and property can be readily identified and they will be used as a basis for safety planning policy formulation.

B. Land Use Impact Identification

The zoning map gives some indication of land use pattern in the City, and also indicates where the majority of population is likely to be during different times of the day. Map 10 on page 27 is divided into four land use categories, based primarilly on the various zoning districts: commercial, industrial, open space, and residential. Each represents a different population profile and a varying population density.

Commercial zones roughly follow Mission, Water and Ocean Streets, and Soquel Avenue with the largest area located west of and adjoining the San Lorenzo River. Pockets of commercial zoning exist near Bay and High Streets, in the Circles area, at the Seabright and Murray intersection, and adjacent to the Yacht Harbor. The commercial areas are used more intensely during the day than at night except the Beach Hill commercial areas. The Beach Hill neighborhood contains the Boardwalk and numerous motels and, as a result, this area has a high night time population as well as a high day time population, on a seasonal basis.

Industrial zones are mainly used during weekdays and are located in outlying areas. There are two major industrial zones in the City—one area is north of downtown between the San Lorenzo River and the University of California and the other is on the extreme west end of town, south of Mission Street.

Open space areas flank the City on nearly all sides. They include DeLaveaga Park and the Yacht Harbor area on the east side, Moore Creek Canyon and Natural Bridges State Park on the far west side, and Harvey West Park and Lighthouse Point to the north and south,respectively. Many of these areas purposely coincide with hazard-prone areas so that areas of potential danger and damage will be void of high-density populations or high intensity uses.

The remainder of the City is devoted to residential use where highest density populations would occur at night. Highest population densities primarily coincide with multi-family zones which include the Downtown neighborhoods, the West of Seabright neighborhood, and the West of Branciforte neighborhood (see Neighborhood Map on page 29).

On page 28, these land uses are overlaid on the hazards that affect Santa Cruz. The following findings are made based on that illustration:

Finding #1: The entire downtown commercial area and most of the Beach Hill commercial area are in a seismic hazard zone.

Finding #2: The entire downtown commercial area and most of the Beach Hill commercial area are in a flood hazard zone.

Finding #3: The highest density residential areas are in a seismic hazard zone.

Finding #4: The highest density residential areas are in flood hazard zones.

Finding #5: The Harvey West industrial area is in a seismic hazard zone.

Finding #6: The Harvey West industrial area is in a flood hazard zone.

Finding #7: Residential areas near DeLaveaga Park and on the far west side are susceptible to fire hazard.

Finding #8: A large number of residential units are susceptible to flooding from Bay Street Reservoir failure.

Finding #9: Major landslide potential exists in the Pogonip Area.

Finding #10: The undeveloped hillside area west of Harvey West Park and the undeveloped portions of Carbonera Estates are susceptible to fire.

Finding #11: Residential uses fronting on West Cliff Drive are susceptible to cliff retreat.

Finding #12: The Santa Cruz City beaches and the Yacht Harbor recreational area are in tsunami inundation areas.

C. City Analysis Areas Impact Identification

In the Housing Element to the General Plan, prepared in 1973, the City was broken down into 17 Analysis Areas. The areas were used as the units of comparison in analyzing housing needs. Since that time, the Analysis Area designations were used in the Noise Element as a framework for illustrating the various noise environments throughout the City.

In an effort to build upon a framework for uniform area analysis, the natural hazard composite map is overlaid on the 17 Analysis Areas to illustrate those areas most susceptible to natural hazards. Based on that illustration, the following findings were made (see Map 11, page 29):

Finding #13: Most of the Downtown (north and south of Lincoln), West of Branciforte, West of Seabright, Beach Hill and River Street Analysis Areas are in seismic hazard zones.

MAP 10

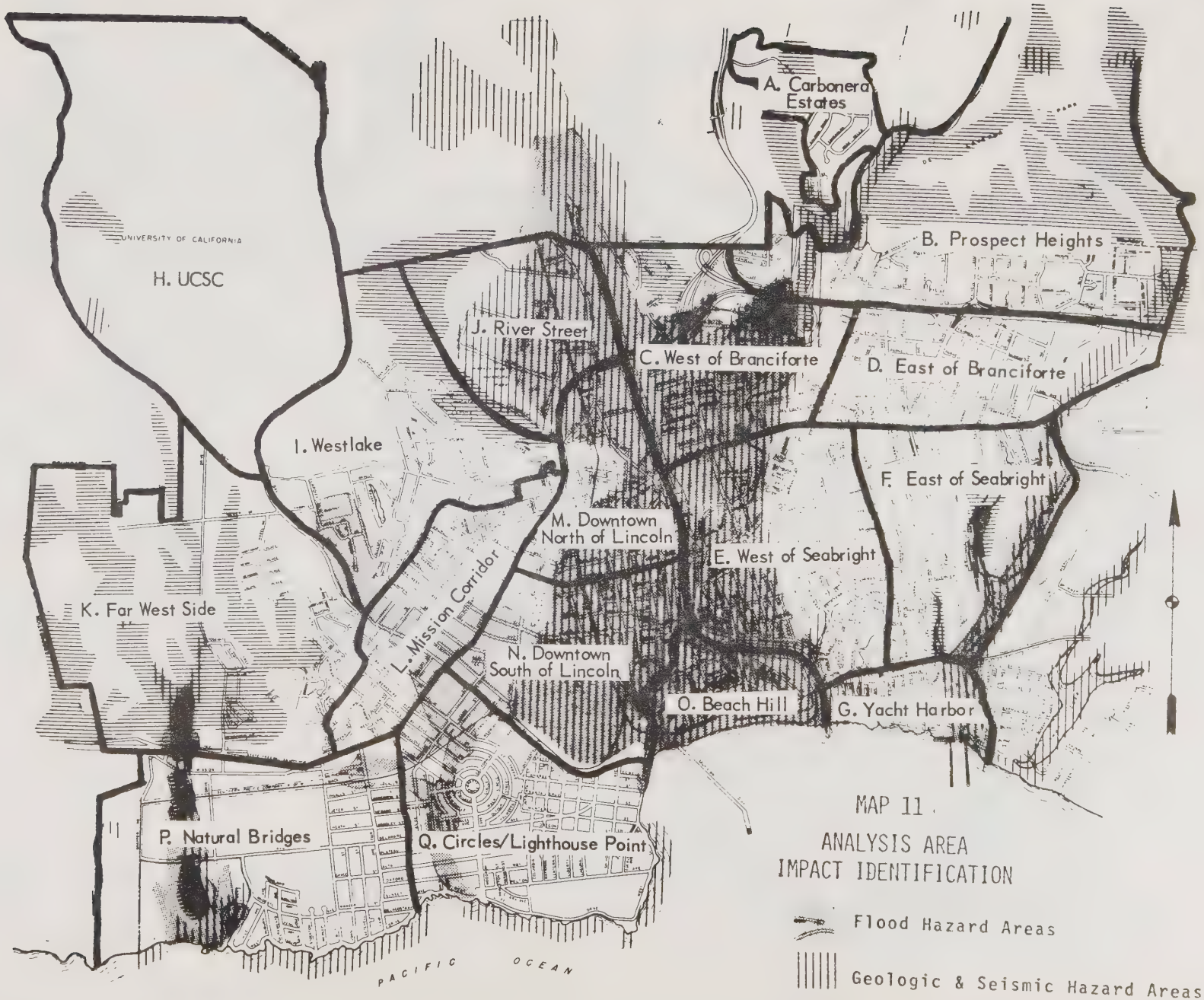
LAND USE IMPACT IDENTIFICATION

Flood Hazard Areas

Geologic & Seismic Hazard Areas

Fire Hazard Areas

R = Residential
C = Commercial
I = Industrial
O = Open Space


A. Carbonera Estates
B. Prospect Heights
UNIVERSITY OF CALIFORNIA
H. UCSC
J. River Street
C. West of Branciforte
D. East of Branciforte
I. Westlake
F. East of Seabright
M. Downtown North of Lincoln
E. West of Seabright
L. Mission Corridor
K. Far West Side
N. Downtown South of Lincoln
O. Beach Hill
G. Yacht Harbor
P. Natural Bridges
Q. Circles/Lighthouse Point
PACIFIC OCEAN
MAP 11
ANALYSIS AREA
IMPACT IDENTIFICATION
Flood Hazard Areas
Geologic & Seismic Hazard Areas
Fire Hazard Areas

Finding #14: Most of the Downtown (north and south of Lincoln), West of Branciforte, West of Seabright, Beach Hill and River Street Analysis Areas are in flood hazard areas.

Finding #15: A portion of the Carbonera Estates Analysis Area is in a fire hazard area.

Finding #16: Portions of the West Lake-Mission Corridor and Circles/Lighthouse Point Analysis Areas are subject to flooding with the failure of the Bay Street reservoir.

Finding #17: The Natural Bridges and Circles/Lighthouse Point Analysis Areas are susceptible to cliff retreat.

Finding #18: Prospect Heights and Far Westside Analysis Areas are susceptible to fire hazards.

D. Major Transportation Route Impact Identification

Major transportation routes, defined as highways and arterial streets, link the neighborhoods of the City and provide essential access both into and out of the hazard-prone areas. The bridges that cross San Lorenzo River provide an essential linkage between the east and west sides of the City. Because mobility of public safety officials and emergency personnel is vital in many emergency situations, and because evacuation relies upon passable and safe roads, transportation routes are a key concern in safety planning.

In an effort to identify important transportation routes for emergency use during a natural hazard, highways, arterial streets, and bridges are overlaid on hazard-prone areas on Map 12, page 31, for impact identification.

The following findings are a result of the analysis of that map:

Finding #19: The hub of the City transportation network is in a seismic hazard zone.

Finding #20: The hub of the City transportation network is in a flood hazard zone.

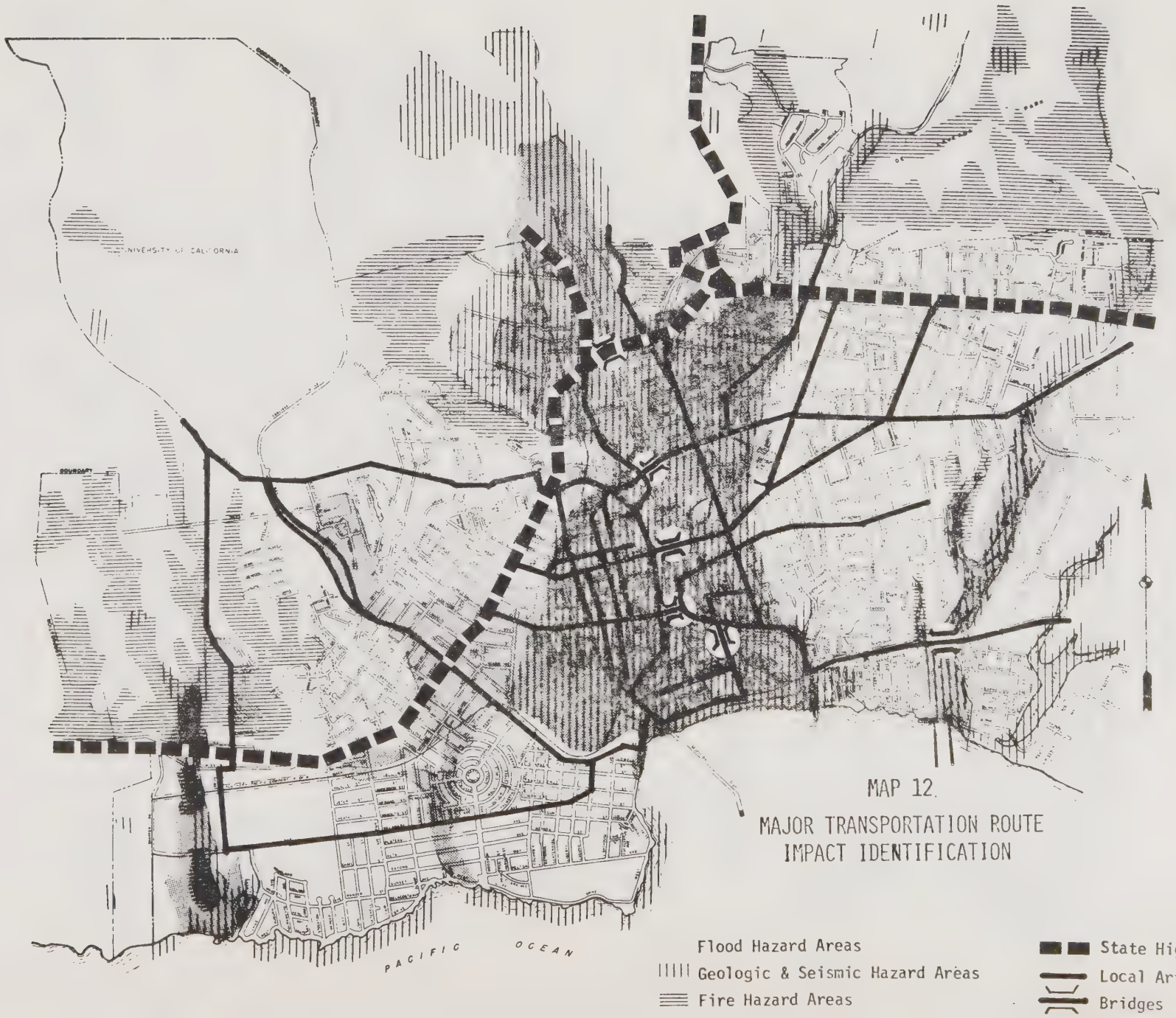
Finding #21: The transportation routes in Santa Cruz are predominantly east-west oriented, thereby crossing through the flood and seismic hazard zone.

Finding #22: All San Lorenzo River bridge crossings are in a seismic hazard zone.

Finding #23: All San Lorenzo River bridge crossings are in a flood hazard zone.

E. Utility Impact Identification

Water, sewage, energy, and phone services are vital to the normal operation of a city and are critical in an emergency situation. For security reasons, the exact location of major gas and electric facilities within the City have not been mapped. However, in those instances where such facilities are located within specific hazard areas, safety policy, developed as a result of this Element, would apply equally to utility company proposals; and they are encouraged to consider such policy in their operation procedures.



MAP 12.

MAJOR TRANSPORTATION ROUTE
IMPACT IDENTIFICATION

Water distribution facilities in the City include a network of lines, the Bay Street Reservoir, and several small reservoirs throughout the City. Facilities outside the City limits include the water treatment plant off Graham Hill Road and the Loch Lomond Reservoir near Lompico. The in-City facilities that are mapped include pipe lines 8 inches and greater, and the Bay Street Reservoir. Eight-inch pipes were designated by the City Water Department as the cut-off size between lines that would be of major and less-than-major significance should they break during a natural disaster.

Sewage facilities within the City include the sewage treatment plan, the East Cliff transmission line, and the sewer line network that serves the neighborhoods of the City. Pipes 10 inches and greater were designated by the City Public Works Department as a dividing point between lines of major and less-than-major significance. Therefore, sewage facilities mapped for impact identification include the sewage treatment facility, the East Cliff Transmission Line and sewage lines 10 inches and greater.

The following findings are made based on Maps 13a and 13b, on pages 33 and 34, which illustrate the relationship between hazard-prone areas and key utility facilities in Santa Cruz.

Finding #24: Water and sewer pipelines connecting East and West Santa Cruz cross through a seismic hazard and flood hazard zone.

Finding #25: The sewage treatment plant is within a seismic hazard zone.

Finding #26: The sewage treatment plant is within a flood hazard zone.

F. Emergency-Related Facilities Impact Identification

There are certain buildings throughout the City that become very important to every resident and visitor of the City during times of emergency. They are the facilities used to coordinate emergency relief operations and to give medical care and shelter to those people directly affected by the emergency situation. The survival of these buildings during times of natural hazards is of prime importance to a successful emergency response plan. These buildings are designated on Map 14 and indexed below:

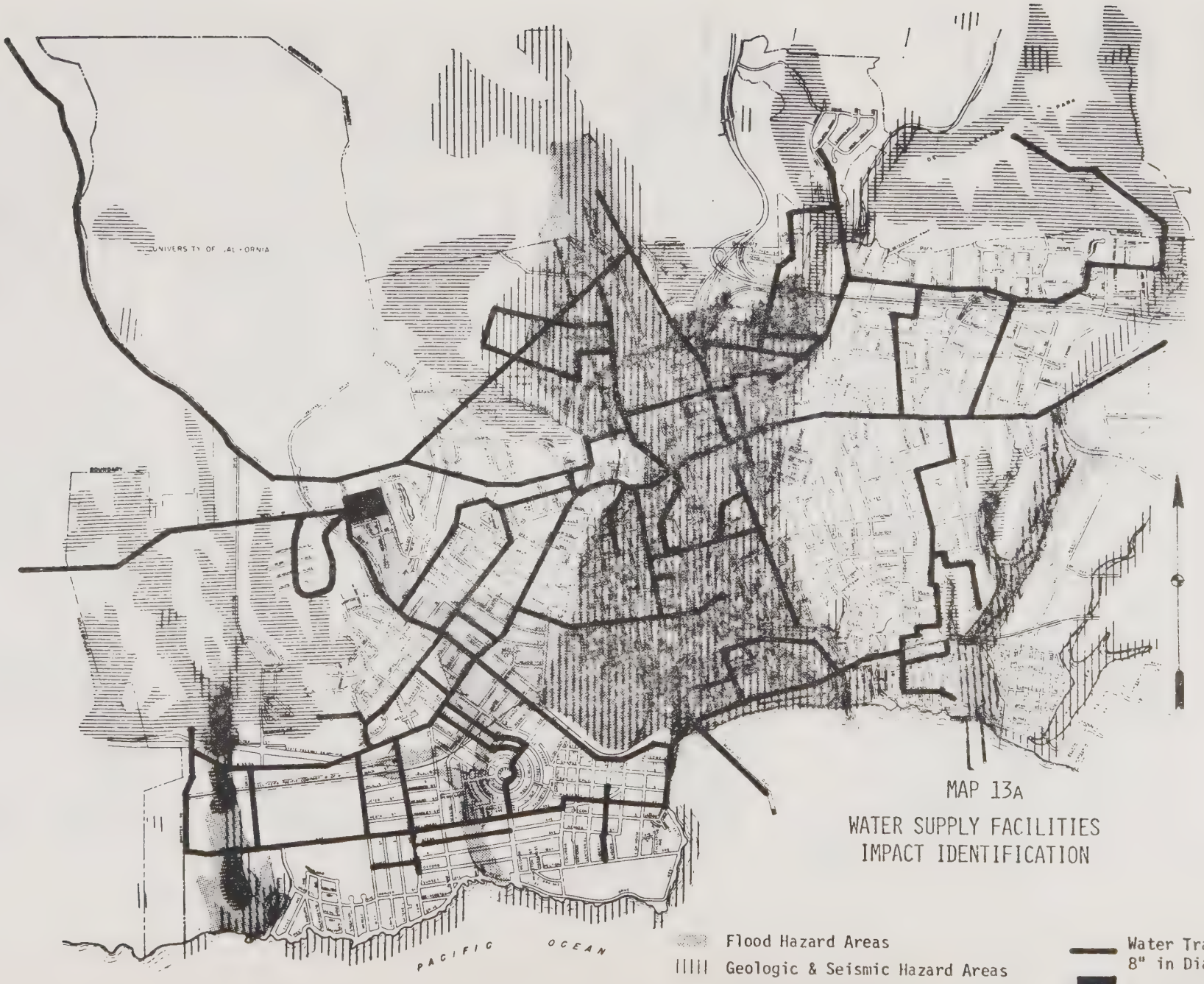
E.....Emergency Center
H.....Hospital
F.....Fire Station
P.....Police Station
S.....School
RC.....Red Cross Mass Care Center

The following findings are made based upon Map 14, page 35, which illustrates the relationship between hazard-prone areas and emergency-related structures.

Finding #27: The County's and the City's main and alternate emergency operation centers are within a seismic hazard zone.

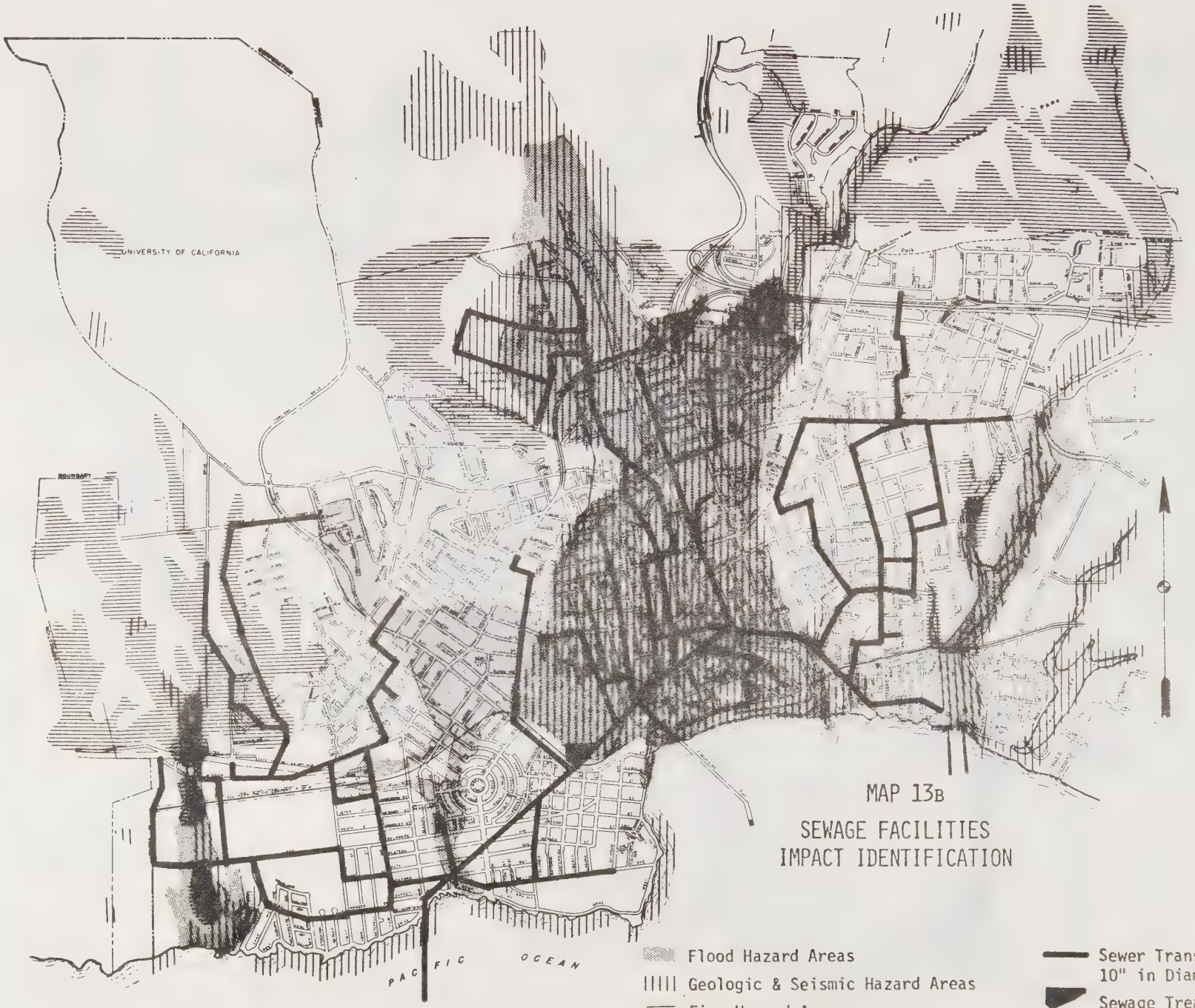
Finding #28: The County's and the City's main and alternate emergency operation centers are within a flood hazard zone.

Finding #29: The main City Fire Station is in a seismic hazard zone.



MAP 13A

WATER SUPPLY FACILITIES
IMPACT IDENTIFICATION



MAP 13B

SEWAGE FACILITIES
IMPACT IDENTIFICATION

MAP 14

EMERGENCY-RELATED FACILITIES IMPACT IDENTIFICATION

Flood Hazard Areas
Geologic & Seismic Hazard Areas
Fire Hazard Areas

E = Emergency Center
F = Fire Station
H = Hospital
P = Police Station
S = School
RC = Red Cross Care Center

Finding #30: The main City Fire Station is in a flood hazard zone.

Finding #31: Two of the three Red Cross mass care centers within the City are in seismic and flood hazard zones.

Finding #32: The major medical facilities within the City are located on the east side of the San Lorenzo River.

Finding #33: Bayview School is subject to inundation from the Bay Street Reservoir.

CHAPTER IV - POLICIES AND PROGRAMS

A. Introduction

The purpose of the Seismic Safety and Safety Element, as stated in the introduction, is to ensure that the proper steps are taken to establish policies designed to reduce the risk from natural hazards. The goal is the attainment of such a reduction. The proper steps within the scope of this document for the accomplishment of this purpose and this goal are: 1) identify the problems (hazards); and 2) suggest solutions (policies). Thus far, the hazards have been defined and mapped (Chapter II), and the problems they present to the City of Santa Cruz have been identified (Chapter III). It is within Chapter IV that policies dealing with these problems will be developed.

In an effort to ensure that step 2, mentioned above, is accomplished efficiently and completely, existing safety policy will first be analysed for the purpose of identifying areas of policy strength, policy weakness, and policy voids. Additional seismic safety and safety findings will be made throughout this analysis. Based on the findings made as a result of this analysis and based on the findins made in Section III, policy recommendations for policy strenghtening and policy development will be made.

B. Analysis of Existing Policies and Programs

Problem-solving policy to protect Santa Cruz from natural hazards has a history paralleling the natural hazards that have plagued or have had potential to plague the City. Past efforts to mitigate the natural hazards that affect Santa Cruz include: The adoption of the first Uniform Building Code in 1927,which contained the first earthquake provisions for structural safety; the construction of levees in 1955,along the San Lorenzo River; adoption of the Open Space and Conservation Element in 1973, that sets policies concerning the appropriate use of flood plans, fire hazard areas and unstable slopes; and adoption of a flood plain ordinance, a grading ordinance, and a conservation district ordinance in 1975, all designed to mitigate environmental hazard resulting from natural or man-initiated causes.

On the following pages, an inventory of existing safety policy and programs is presented in the areas of disaster planning, development controls, general plan elements and general policy in an attempt to illustrate the existing state of a seismic safety and safety policy.

1. City Disaster Planning

It is difficult, if not impossible, to anticipate all the problems one would encounter in an emergency situation, or anticipate the scope of a disaster. Despite any amount of planning, people tend to panic in disaster situations. Nonetheless, disaster planning is essential to the reduction of loss of life and damage to property.

a. City Disaster Plan: The City of Santa Cruz has a "Civil Defense and Disaster Operational Plan". The existing plan was adopted by the State of California in June, 1975. Such plans are normally updated bi-annually. The plan is focused, as is mandated by Federal

law, on war-caused disaster, but includes a section on natural disasters. The Operational Plan provides an outline of responsibilities for the various agencies within the City and is used as the basis for developing specific City departmental emergency response plans. The operational plan lists the legal basis for action and describes who shall constitute the disaster council, which is the decision-making body in emergency situations. The organization chart (Figure 2, page 38) sets forth areas of responsibility in the City during times of emergency.

Finding #34: Response plans provide detailed information necessary for implementation of City emergency procedures. They are reviewed and revised on a periodic basis.

In an effort to describe the key elements of emergency preparedness in Santa Cruz, the following emergency services, emergency facilities and utility contingency plans are outlined.

b. Emergency Services:

Fire Protection—The Fire Department maintains three stations in the City (see Map on page 34). Their role in disaster situations is to perform rescue operations and suppress fires. Naturally caused fires (lightning, dry vegetation) are not a significant problem in the urbanized areas of Santa Cruz, but do pose a hazard to outlying areas. Fires, however, often accompany other disasters such as earthquakes which can rupture gas lines and down electrical lines.

Water used to suppress fires comes from the City water lines. Hydrants tap 3-inch to 10-inch diamter water lines; those over 6 inches in diameter are considered "good" as they can produce 1000 gallons per minute. In the event a water line is broken, the Fire Department, as well as the Water Department, has the capability to cut off the water flow through the damaged pipe or area.

Should fires occur in areas where water lines are damaged, the Fire Department has two tankers with 2,000 and 5,000 gallon capacities. They also have pumps (as does the Sewer Department) with which they can refill their tankers from a reservoir or the San Lorenzo River, or pump water into water lines. The Fire Department uses its regular enginers and ladder trucks for rescue operations and personnel are trained in advanced first aid.

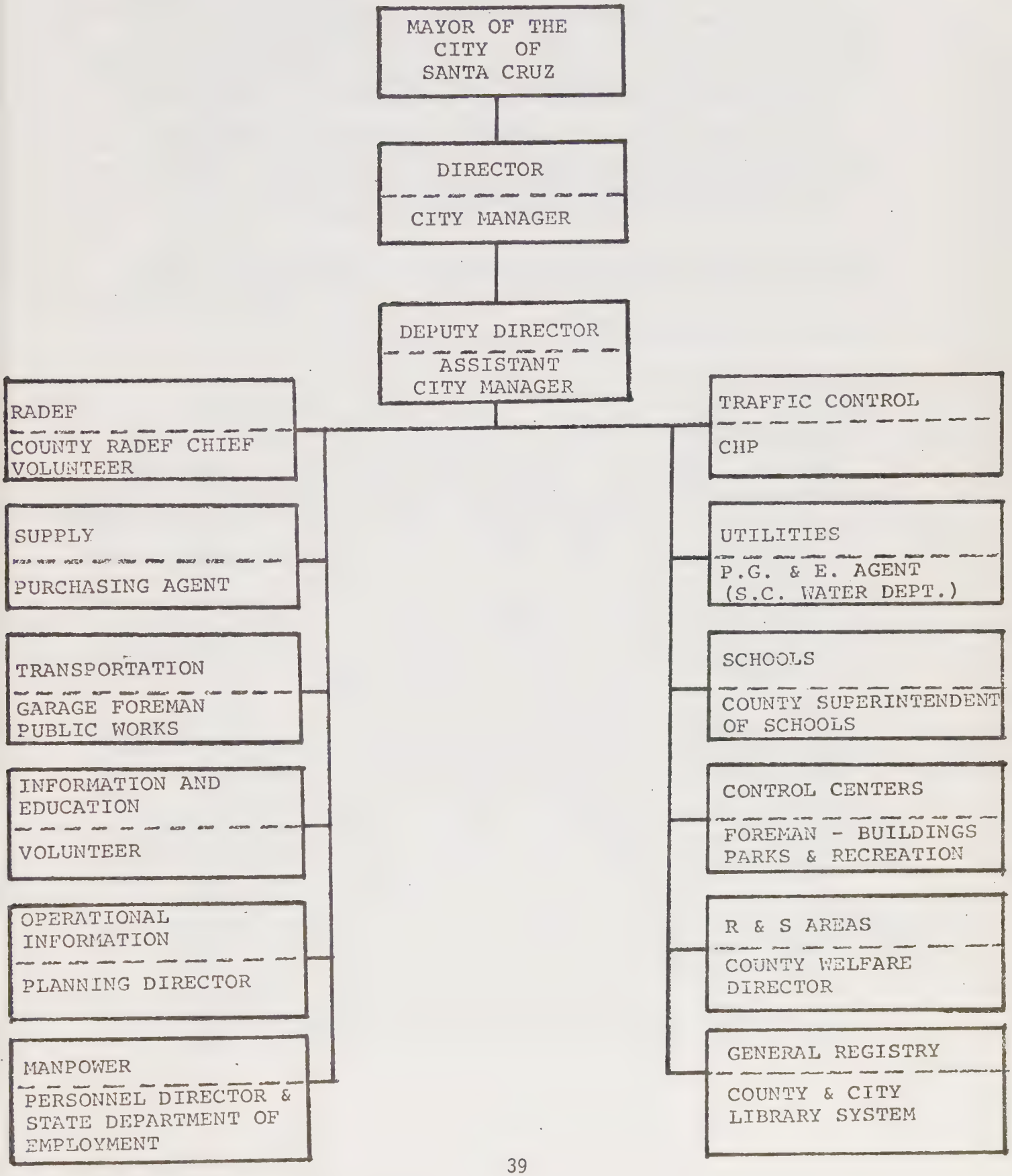
Police Assistance—The Santa Cruz Police have a "general order" which outlines the mobilization of officers in the event of a disaster. Their office in City Hall is designated by the operational plan as a main Emergency Operation Center for the City. They also have the flexibility to move to alternate sites should their headquarters be incapacitated. Their second choice headquarters site would be the East and/or the West Fire Stations. Their emergency center and alternative emergency centers would be the communications center during emergency situations but they do not have emergency housing, medical, or food provisions.

Building Inspection—The Santa Cruz City Building Inspection Services is mobilized during times of emergency for their effectiveness

FIGURE 2

CITY OF SANTA CRUZ
CIVIL DEFENSE AND DISASTER
ORGANIZATION CHART

"SPECIAL SERVICES"



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in determining structural safety. Often times, the building inspectors must be the first to enter damaged buildings. It is their task to determine the structural condition and safety of buildings throughout the community, especially those with high occupancy capacity. Buildings are posted by the inspectors, when they represent a threat to their occupants, indicating their potential danger.

Depending upon the extent of damage to the City, mutual aid is often rendered by building officials from other local and state agencies.

Medical Agency Assistance—The medical community has developed a detailed response plan, entitled the "Santa Cruz County Civil Defense and Disaster Medical and Health Plan". In preparation of their plan, they disregarded political boundaries within the County; thus, the City is covered by the County's Medical Response Plan.

National statistics indicate that only 50% of the emergency personnel will be able to reach disaster centers and perform their duties. The response plan is written so that the first person to arrive at an emergency center can begin disaster procedures and relinquish authority as those with more responsibility arrive.

The medical plan is the first in the nation to utilize taxis as a back-up emergency transportation and communications network.

The response plan is quite thorough and includes: (1) list of hospitals and their size and facilities; (2) list of doctors and their hospital assignments in the event of an emergency; (3) list of dentists and veterinarians to be used as surgical assistants; (4) assessment and floor plans of alternate emergency facilities; (5) emergency hospital teams and their assignments; (6) materials required to set up an emergency hospital; (7) lists of medical field teams who move to the disaster site and assess medical injuries; (8) list of first aid stations; (9) list of essential drugs; and (10) list of child-care centers for the disaster workers' children.

The medical and health plan also includes a blood program utilizing the County's 750 blood drawing units, and a public health program to be administered through the public health office.

Red Cross Assistance—The role of the Red Cross Disaster Program under Federal law (Disaster Relief Acts of 1970 and 1974) is to help meet the human needs that a disaster has caused. The Santa Cruz Red Cross Chapter has a mandated responsibility and is prepared to offer a number of services to disaster victims in need. These include registration, transportation, canteen, housing, feeding, clothing, first aid, nursing, disaster inquiry and recovery services. The local Red Cross has an agreement with Teleprompter Cable TV of Santa Cruz through which a unique disaster mobile communications network is provided to Red Cross diaster officials. Twenty-five Teleprompter trucks equipped with two-way radios are available for use at widely scattered points.

The County's Emergency Welfare Services Disaster Plan is written to coordinate County agency efforts with Red Cross efforts. The Plan

is designed to permit rapid and effective response in a major disaster while the American Red Cross in mobilizing additional personnel from other parts of the United States, when necessary.

Early Warning System—The National Weather Service provides continuous weather radio service to the entire Monterey Bay Area from Mount Umunhum, located about 15 miles NNE of Santa Cruz. The service is designed to speed warnings of natural disasters and national emergencies to the general public and emergency action units.

Weather radio broadcasts, on frequency of 162.400 and 162.550 Megahertz, are made from National Weather Service Offices 24 hours a day. Taped weather forecast messages are repeated every 4 to 6 minutes and are routinely revised every 2 to 3 hours, or more frequently if needed.

During emergency situations, National Weather Service forecasters can interrupt the routine weather broadcast and substitute special warning messages.

The County Emergency Operations Center monitors weather forecasts for early-warning messages.

c. Emergency Facilities-Emergency Operating Centers: The City's emergency centers (the City Policy station and the City Corporation Yard), are only equipped to serve as communications centers. Both are currently used to capacity in their normal functions as City offices and for equipment maintenance. The City's central store is located in the maintenance yard and would be a source of valuable equipment (shovels, work clothes, rope, cable, drinking cups, flashlights, batteries, lanterns, etc.) in the event of a disaster. An average of 8,000 gallons of diesel fuel is stored there as well.

The County's Emergency Operating Center located in the basement of the County Building can also serve the City should the City Building Emergency Center be incapacitated. The County alternate Emergency Centers are the current jail on Front Street and a mobile unit which can be moved to any location.

The Emergency Operating Center in the basement of the County Building is well-equipped to handle various diasters and is, in fact, the largest center of its kind in the United States. It includes: 8-bed infirmary, two 200-bed dormitories, a 2-week food supply in the cafeteria, its own well, rooms for emergency services, direct radio communication with emergency service agencies, other counties, and Sacramento for mutual aid, and station KSCO which serves as the Emergency Broadcasting Station for the Tri-County Area (Santa Cruz, Monterey, and San Benito).

d. Utility Services: Utilities are vital to the functioning of any city. In reviewing the City's capability to handle various disasters, gas, electric, telephone, water, sewer, and road maintenance services, and their contingency plans were analyzed.

Telephone—The phone company operates transmission lines roughly following major transportation routes. Both major phone line river

crossings are undergrounded. Should a power loss occur, they have 24-hour back-up battery power and a 30-day generator back-up capacity.

Trees falling across lines are a somewhat normal occurrence and can be readily repaired. Mobile phone units are available within the City and County with back-up units available from both San Francisco and Salinas. An internal walkie-talkie system connects all phone company vehicles with the central office. The phone company also maintains an essential phone services list to determine which phone services would be reconnected first. Toll cables which connect Santa Cruz with other areas follow Highways 17 and 1.

Electricity—There are no major electric transmission lines (60,000 volts and above) within the City of Santa Cruz. Major transmission lines terminate northeasterly and easterly of the City and are broken down to 21,000 volt lines which traverse nearly all of Santa Cruz. A few of the older 4,000 volt lines still exist, but these are being slowly replaced by the 21,000 volt system. The existing electric distribution system is a fully integrated network which allows for the rerouting of electric supplies should a portion of the system be damaged during a seismic event.

Gas—As with electricity, major gas lines come to Santa Cruz from the northeast and east, and terminate beyond the City limits. Within the City there are two gas line crossings of the San Lorenzo River.

Gas regulator stations are all located in underground pits. These pits are constructed to avoid the usual moisture that accumulates and, as such, are fairly impervious to water. A gas-holding facility exists which could provide the City with a limited gas supply, should gas from the outside be cut off following a seismic event.

Sewage—The disruption of sewage disposal service can cause a major health hazard. In order to provide continuity of service, the Public Works Department has a brief contingency plan outlining their capabilities in the event of various diasters.

The sewage treatment plant has an emergency power generator which can fulfill their total sewer operation energy needs. The City's sewage treatment facility is located within the Neary's Lagoon area but is protected from flooding by a dike.

The sewer lines that serve the City (see Map 13b, page 34) are susceptible to breakage through earthquake damage. Sewer lines cross under the San Lorenzo River where the velocity of floodwaters is decreased as it piles up against Bay waters.

Water—The City of Santa Cruz has three major water sources—Loch Lomond Reservoir, coastal streams, and the San Lorenzo River—each providing roughly a third of the City's water needs. The water distribution system utilizes a network of pipes from 3 inches to 36 inches in diameter (mains 8 inches and above are mapped on page 33). Pipelines cross the San Lorenzo River at all major bridges and at Tait and Josephine Streets. Distribution within the City is also

facilitated by several pumping stations and reservoirs. The pumping stations are generally above ground (one underground station), and built to earthquake zone standards. In the event water pipes are damaged, both the Fire and Water Departments can isolate the damaged area.

Reservoirs of various capacities serve the City and are automatically refilled if they go below the three-fourths-full level. The major reservoir within the City on Bay Street is kept near capacity (34 million gallons out of the 39-million maximum).

Loch Lomond Reservoir at Newell Creek Dam has a maximum capacity of 2,800,000,000 gallons. The reservoir level fluctuates but contains a minimum of 2,275,000,000 gallons or 7,000 acre feet.

In the event of a disaster, the greatest threat from water facilities is from the possible failure of either the Bay Street or Loch Lomond Reservoirs. However, as described below, there are ample checks on the structural safety of both reservoirs that substantially mitigate the threat of such failures. The County Civil Defense Office is currently (1976) preparing warning and evacuation procedures for inundation areas from both reservoirs. Water main damage can generally be controlled locally; thus, does not pose a major threat.

The Bay Street Reservoir is equipped with an alarm that activates a light and buzzer at the water treatment plant when a low level is reached. Personnel at the water treatment facility (staffed 24 hours per day) then notify maintenance personnel. Notification and response time is estimated at 20 minutes. Inundation studies for the reservoir indicate that flood waters from the reservoir would reach the ocean in 30 minutes which leaves little time for effective flood warning.

It should be pointed out, however, that the Bay Street Reservoir is maintained in accordance with California Division of Safety of Dams regulations. The State agency requires that embankment drains and underground drains be monitored monthly for hydrology deviation; and that the vertical and horizontal alignments of the structure be monitored semi-annually for bending, twisting and possible uplifting. To date, there has been no evidence of failure in the Bay Street Reservoir structure. It was constructed in 1927.

Finding #35: The Bay Street Reservoir represents a potential flooding threat to portions of the west side of Santa Cruz. Whereas dam safety measures substantially mitigate the potential hazard, evacuation plans are in preparation by the County Civil Defense Director in compliance with State requirements.

Newell Creek Dam (Loch Lomond Reservoir) poses a substantial threat to the City should a dam failure occur. A pressure gauge is located in a water main below Loch Lomond and pressure is continuously plotted and checked hourly at the water treatment plant. When the chart indicates a major change in pressure, maintenance personnel are notified. Should the change in pressure be caused by a major

dam failure, maintenance personnel and equipment would naturally be inadequate. Inundation studies for the reservoir indicate that flood waters from the reservoir would reach the intersection of Highway 1 and 17, forty-five minutes after dam failure, based on a full reservoir situation. Again, however, measures are taken by the City, identical to those mentioned above relative to Bay Street Reservoir, that substantially reduce the risk of such an occurrence. Newell Creek Dam was constructed in 1961, and, to date, there has been no evidence of failure in the dam.

Finding #36: The Newell Creek Reservoir represents a potential flooding threat to Santa Cruz. Whereas dam safety measures substantially mitigate the potential hazard, evacuation plans are in preparation by the County Civil Defense Director in compliance with State requirements.

Energy needs of the water treatment plant and pumping stations can partially be met by back-up generators and turbines, should a natural disaster destroy the normal energy supply. A minimum of six months' supply of chemicals for water treatment is also stockpiled should normal chemical sources be unavailable in a disaster.

Road Maintenance—Clearing roads is critical in emergency situations to allow access into and out of disaster areas. Roads can be blocked by any natural disaster—flood waters, earthquake rubble, or snow and ice.

The City Road Maintenance Division of the Public Works Department has a wide range of road-clearing equipment. They also stockpile a few-hundred empty sandbags (kept empty to prevent rotting) and sand. More sand is readily available within a 3- to 5-mile radius.

Bridges are critical connectors of the east and west sides of town. During heavy rains, bridges are patrolled to check for log jams, one of the greatest dangers to the bridges. The bridges constructed since 1955, were designed to withstand a 100+-year hypothetical storm. The Riverside Bridge, constructed prior to 1955, has been maintained at its previous capacity, but wingwalls were added to prevent the buildup of debris.

2. City Development Controls

Development within the City of Santa Cruz is currently controlled by the Santa Cruz Municipal Code. Title 18 (Building and Construction), Title 23 (Plats and Subdivisions), and Title 24 (Zoning) contain development controls reflecting seismic safety and safety mitigation measures.

a. Title 18: Title 18 includes the Santa Cruz City Building Code (UBC). Santa Cruz adopted the first edition of the UBC in 1927 and, since that time, has adopted each subsequent edition. The UBC is revised every three years; 1976 being the next scheduled edition.

The UBC contains general construction safety regulations and, in addition, contains earthquake regulations that govern the construction of buildings. The UBC recognizes three seismic zones through the country and regulates construction accordingly. Santa Cruz

is within the highest risk zone, therefore regulated by the most restrictive earthquake construction standards.

Earthquake regulations have appeared in each edition of the UBC since the first edition in 1927. The regulations are based upon the most recent understanding of earthquakes and the most recent technology in earthquake hazard mitigation. As an example, the 1973 code reflects what was learned about structural safety from the destruction caused by the 1971 San Fernando Valley earthquake.

Earthquake regulations are found in the UBC under Section 2314. The introductory subsection states "Every building or structure and every portion thereof shall be designed and constructed to resist stresses produced by lateral forces as provided in this section. Stresses shall be calculated as the effort of a force applied horizontally at each floor or roof level above the foundation. The force shall be assumed to come from any horizontal direction".

In addition: "The provisions of this section apply to the structure as a unit and also to all parts thereof, including the structural frame or walls, floor and roof systems, and other structural features."

The UBC regulations govern design requirements, construction, minor alterations, reinforced masonry or concrete, combined vertical and horizontal forces, and exterior elements. It also provides for earthquake recording instruments in certain buildings in excess of six stories and all buildings in excess of ten stories.

The UBC also contains the Uniform Code for the Abatement of Dangerous Buildings, which effects the condemnation or removal of unsafe structures.

Structural safety plays an important role in seismic safety planning in urbanized areas. Whereas, limiting or preventing development is an excellent safety planning policy for those undeveloped lands within seismic-prone areas, seismic safety policy in developed areas must rely on adequate structural control. In Santa Cruz, the UBC, including the Uniform Code for the Abatement of Dangerous Buildings, provides for such control.

Finding #37: Santa Cruz, being an urbanized area, relies heavily on the UBC for seismic safety.

b. Title 24: Title 24 is the Santa Cruz City zoning ordinance. The ordinance consists of land use regulations designed to protect and promote public health and safety and encourage orderly and beneficial uses of the land. Whereas, the entire ordinance reflects the protection and promotion of public health and safety, three chapters have been adopted specifically for that purpose. They are Chapter 24.16, Part 4 (Flood Plain District), Chapter 24.21 (Conservation Combining District), and 24.27 (Excavation and Grading).

Flood Plain District—The purpose and intent of the Flood Plain District is to protect the public health, safety, and welfare through regulation of uses in area which are unprotected from flooding or are required to carry the flood flows of the stream. New

construction in the Flood Plain District is regulated so that it is protected against damage and located to avoid causing excessive increases in flood heights or velocities.

Through the provisions of this chapter, its application to the flood-prone areas, and the recently adopted (May, 1975) Federal Flood Insurance Program, the City of Santa Cruz has developed and implemented adequate flood safety policy for unprotected floodways, thereby reducing the risk to life and property from river and stream flooding.

Conservation Combining District—The purpose and intent of the Conservation Combining District is to protect the public health, safety and community welfare; and to otherwise preserve the natural environmental resources of the City of Santa Cruz in certain selected areas having significant and critical environmental characteristics.

Whereas, the Conservation Combining District has yet to be applied to zones in the City (as of December, 1975), it is primarily designed to control development on steep slopes, near fire-hazard zones, adjacent to riparian habitat, and within groundwater recharge areas. In all cases, the regulations are intended to prevent environmental damage; damage that not only degrades the quality of the environment but enhances the chance of a hazardous occurrence. Construction of unstable slopes can trigger a landslide. Development near fire hazard areas can result in brush and forest fires. Clearing of riparian habitat can increase sedimentation, thereby increasing localized flooding. Inadequate groundwater recharge can cause ground subsidence and also result in increased runoff.

Through the application of the Conservation Combining District, such hazards can be mitigated.

Excavation and Grading—The chapter on Excavation and Grading sets forth rules and regulations to control excavation, grading, and earthwork construction, including fills and embankments. The purpose of the chapter is to safeguard the public health and safety and the general community welfare, and to otherwise protect natural environments of the City of Santa Cruz. In conjunction with the Conservation Combining District, the Excavation and Grading Ordinance adequately regulates development on unstable slopes; thereby reducing risk to life and property from landslides.

3. Policy Basis of the Planning Program

On October 12, 1971, the 1964 City General Plan was amended through the adoption of the Santa Cruz City Policy Basis of the Planning Program. The Policy Basis was the first step in updating the General Plan and incorporating into the City long-range planning program, the citizen goals as enunciated in the 1970 C-PAC Report. The Policy Basis establishes a verbal base for directing the ensuing planning program and clearly defines the official policy regarding the future of the City of Santa Cruz.

Contained in the Policy Basis are the following policies and programs designed to reduce the risk from hazardous events in the City of Santa Cruz:

Policy - "Dwellings should not be permitted in locations subject to flooding, areas too steep to develop, sites made unstable

when graded, and when other natural occurrences pose a serious potential hazard."

This City policy is reflected in the Flood Plain District, Conservation Combining District, and Excavation and Grading Ordinance.

Program - "Delineate areas where potential physical hazards may endanger buildings and their occupants; amend codes to ensure that development is adequately controlled in these areas."

This program has been initiated by the adoption of the Open Space and Conservation Element and the subsequent adoption of Flood Plain District, Conservation Combining District, and the Excavation and Grading Ordinance. The Seismic Safety and Safety Element represents an addition to this program.

Policy - "Areas susceptible to severe earthquake damage, flooding, landslides, slumping, and fires should be utilized for open space purposes."

This City policy is reflected in the Flood Plain District, Conservation Combining District, and the Excavation and Grading Ordinance.

Program - "Prepare a detailed study of the geologic framework with special studies on active faults, frequency of earthquake activity, and effects of past earthquakes as well as areas subject to massive landslides and slumping."

This program was initiated with the City's involvement in the preparation of the county-wide Seismic Safety Element prepared by the United States Geological Survey (USGS). The information generated in the County Element is the basis for the preparation of the City Element. The completion of this Element, however, should not be considered the completion of this Policy Basis program. Earthquake technology advances should be reflected in a continuing planning process.

Program - "Delineate areas unsafe for urban development and prepare appropriate regulations to prohibit development."

This program has been initiated by the adoption of the Open Space and Conservation Element and the subsequent adoption of Flood Plain District, Conservation Combining District, and the Excavation and Grading Ordinance. The Seismic Safety and Safety Element represents an addition to this program.

4. General Plan Element

It is the purpose of the Seismic Safety and Safety Element to reduce risk from natural hazards. This element, however, is not the only element containing policies designed to make Santa Cruz a safer place in which to live. Currently, the City has 3 adopted General Plan Elements: Housing,

Open Space and Conservation, and Historic Preservation. All three, either directly or indirectly, contain policies intended to reduce danger to people and property from natural hazards.

a. Housing Element: The Housing Element establishes 14 housing goals for Santa Cruz; all designed to improve the housing stock in particular, and the quality of life, in general, for Santa Cruz. Among those goals is "rehabilitate or replace all substandard housing with standard housing on at least a one-to-one basis". Accompanying the statement of the goal is an identification of substandard housing neighborhoods within the City. Map 15 on the following page illustrates those areas containing 16% or more substandard housing.

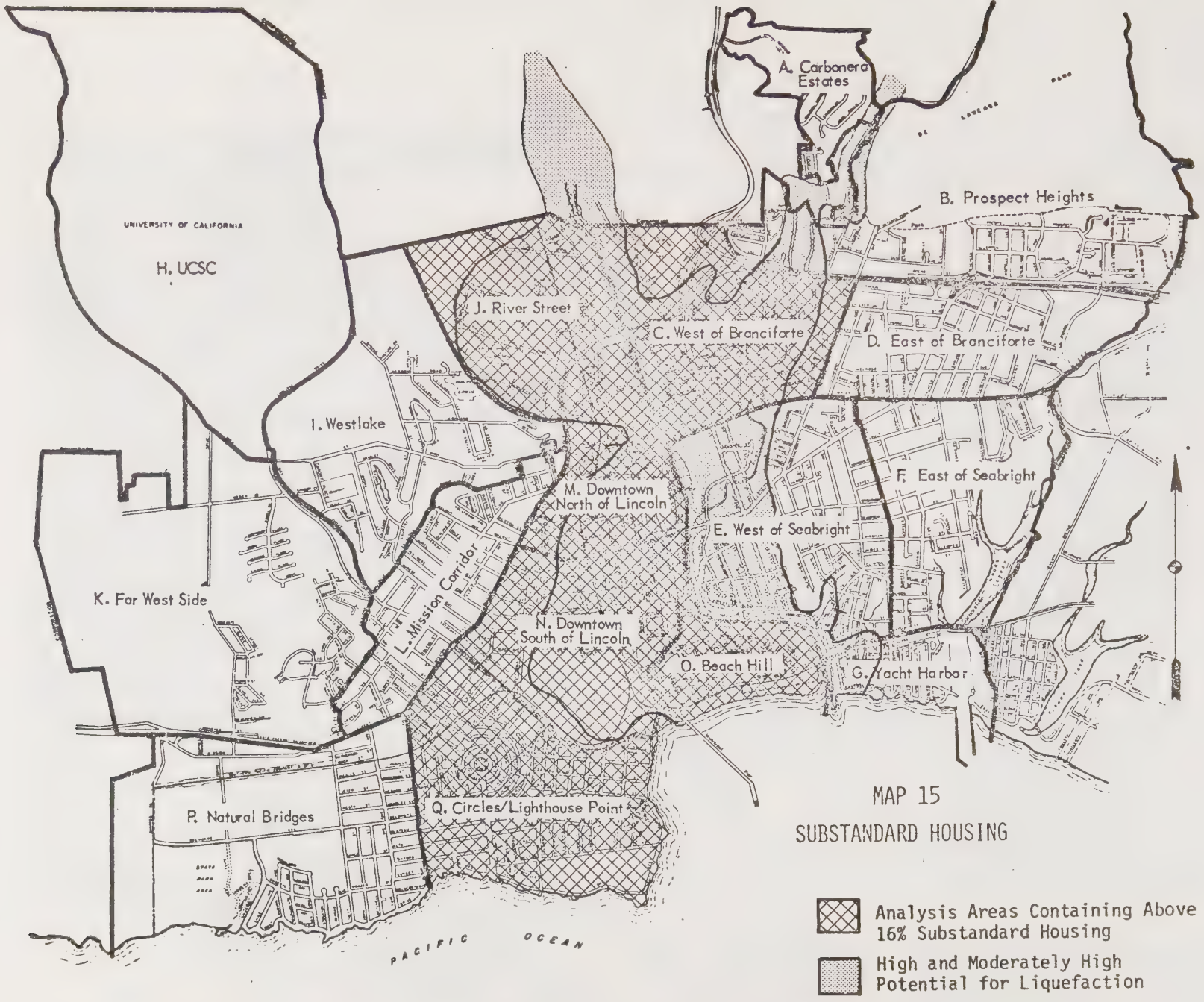
With the seismic hazard-prone areas overlaid by Map 15, it is easy to see that a compound problem exists: those areas most susceptible to seismic hazard are also heavily occupied by substandard housing. This illustration points out a commonly shared problem between housing and seismic safety concerns: Unsafe structures. And,in this case, the solution can also be commonly shared. Rehabilitating structures to improve a socially undesirable situation also reduces the risk associated with poor construction in a seismic hazard-prone area. Indirectly then, there is existing seismic safety policy contained in the Housing Element.

Finding #38: Housing in greatest need of rehabilitation is located within a potential liquefaction area.

b. Open Space and Conservation Element: The Open Space and Conservation Element built a framework for identifying types of open space and their uses. A portion of that framework deals with public health and safety concerns; the same concerns of the Seismic Safety and Safety Element. They specifically include slopes, erosion hazard areas, seismic hazard areas, flood plain areas, tsunami inundation areas, and fire hazard areas. In an effort to protect people from irrational uses of these areas, safety objectives were defined and policies and programs were recommended (and adopted).

The public health and safety policies and programs contained in the Open Space and Conservation Element are designed to preserve open spaces which are required for the protection of man from natural hazards in certain areas of the City. Those policies and programs include: controls for development on slopes 15% or greater; environmental impact review for development near fault zones, on unstable slopes and near fire hazard areas; a flood plain ordinance; and a grading ordinance. Such controls reduce risk from natural hazard. There are then, existing seismic safety and safety policies contained in the Open Space and Conservation Element; policies that, for the most part, have been implemented and that reduce risk from natural hazard.

c. Historic Preservation Element: The Historic Preservation Element has a less direct relationship with the Seismic Safety and Safety Element. The purpose of historic preservation is to preserve individual structures and areas of architectural and historic significance. Maps 16 and 17, pages 50 & 51, illustrate historic buildings and historic areas in Santa Cruz as designated in the Historic



MAP 15

SUBSTANDARD HOUSING

Analysis Areas Containing Above 16% Substandard Housing

High and Moderately High Potential for Liquefaction

MAP 16

HISTORIC BUILDINGS SUBJECT TO LIQUEFACTION

B Spanish Style
130 School Street
C Pioneer Style
109 Sylvar Street
D Greek Revival Style
152 Center Street
E Gothic Revival Style
532 Center Street
F Italianate Style
170 West Cliff Drive
G Stick Style
419 Locust Street
H Eastlake Style
724 California Street
I Romanesque Style
1352 Pacific Avenue
J Queen Anne Style
304 Walnut Avenue
K Colonial Revival
303 Mission Street
L Shingle Style
924 Third Street
M Mission Revival Style
260 High Street
N California Bungalow Style
1107 Mission Street
O Spanish Revival Style
215 Beach

MAP 17

HISTORIC AREAS SUBJECT TO LIQUEFACTION

A-1 Mission Hill Area
A-2 Oceanview Avenue Area
A-3 Lincoln Street-Walnut Avenue Area
A-4 Beach Hill Area
A-5 Riverside Avenue Area
A-6 Highland Avenue-Storey Street Area
A-7 Union-Locust Street Area
A-8 Castle Beach Area
A-9 Lighthouse Point Area
A-10 Cowell Ranch Area
A-11 Evergreen Cemetery
A-12 IOOF Cemetery
A-13 Home of Peace Cemetery
A-14 Pacific Garden Mall

HIGH POTENTIAL FOR LIQUEFACTION

MODERATELY HIGH POTENTIAL FOR LIQUEFACTION

Preservation Element. An overlay of seismic hazards indicates that a considerable number of these buildings and areas lie in the seismic hazard zone; illustrating not necessarily a common problem, but a common geographical area of concern.

An important element of preservation is the prevention of building deterioration and decay through various rehabilitation programs. A tool of the Historic Preservation Element is the rehabilitation of unsafe historically and architecturally significant buildings for the purpose of maintaining a diverse building heritage in the City, as well as improving the housing stock. As stated earlier under Housing Element discussion, such action may also reduce risk from seismic hazards.

It should be pointed out that historic preservation has potential for conflict with the Seismic Safety and Safety Element. Whereas it is not evident in the Santa Cruz Historic Preservation Element, attempts at preserving historic structures can result in the preservation of structures representing a high risk situation during a seismic event. Should such a conflict arise in the implementation of either element, it will be incumbent upon the City decision-making bodies to define an acceptable level of risk relative to the situation in order that the potential conflict may be resolved.

Finding #39: Six historic structures, and six historic areas are totally or partially within seismic hazard areas.

d. Other Elements: The relationship of the Seismic Safety and Safety Element to the remaining unadopted elements will vary in degrees of correlation. Relative to the Land Use and Circulation Elements, scheduled to be completed in 1977, the Seismic Safety and Safety Element should provide significant input towards determination of land use designations. Relative to the Noise and Scenic Highways Elements, scheduled to be completed in early 1976, there should be little, if any, relationship with the Seismic Safety and Safety Element.

5. Summary of Existing Policies and Programs

In Santa Cruz, structural safety and disaster planning have been, and continue to be, the two major safety planning considerations. The foregoing descriptionsof existing policies and programs indicate that both safety considerations are currently addressed by existing City policy.

Structural safety of private buildings,and public and semi-public facilities is governed by the Uniform Building Code, Fire Code, Zoning Ordinance, General Plan and its Elements, the State Division of Safety of Dams,and other safety-related agencies and documents. With the adoption of such control mechanisms, active consideration for structural safety has been set into motion and is continued through the required implementation techniques called for by the various safety-related agencies and documents.

Disaster planning in Santa Cruz has been undertaken by public as well as semi-public agencies. The County has an up-dated Emergency Operational

Plan that acts as the backbone and as a framework for the development of specific emergency response plans. The various City Departments have developed such response plans. They represent a coordinated effort on the part of the City to respond to the needs of the citizens of Santa Cruz in any emergency situation. Such response plans are updated on a periodic basis for maximum readiness.

The utility companies, whose services are of the utmost importance in emergency situations, have developed plans for maintaining their services to the extent possible, in the event of a disaster.

C. Seismic Safety and Safety Policy—Summary of Existing and Proposed Policies

The Seismic Safety and Safety Element, to this point, has pointed out that Santa Cruz is susceptible to various natural hazards and that Santa Cruz has developed policy and programs to deal with such hazards. However, whereas existing policy and programs effect a substantial reduction in risk from natural hazards, policy and program voids have been identified as a result of comparing impacts (Chapter III) with existing policies and programs (Chapter IV, Part B). The policy statements contained in this section are a combination of existing policy and new policy. Together, they mitigate those potential natural hazard impacts identified in the Element. The policy areas are divided into five categories:

1. Policies designed to mitigate seismic hazard findings.
2. Policies designed to mitigate cliff retreat findings.
3. Policies designed to mitigate flood hazard findings.
4. Policies designed to mitigate fire hazard findings.
5. Policies designed to improve City disaster planning.

The existing policy and the new policy statements are correlated with the finding numbers in Chapter III (Impact Identification) and Chapter IV, Section A (Analysis of Existing Policies and Programs) to illustrate the relationship between the identification of potential impact and the mitigation of potential impact.

1. The following policies are designed to mitigate the seismic hazard findings made in Chapters III and IV.

a. Existing policies

—The City adopted the first Uniform Building Code (UBC) in 1927, including the Code's earthquake provisions and has adopted each subsequent addition including the 1973 edition.
(FINDINGS 1,3,4,25,29,37,38 and 39)

—The City adopted the Uniform Code for the Abatement of Dangerous Buildings. Numerous hazardous structures have been abated in accordance with the Code's provisions.
(FINDINGS 1,3,5,37,38 and 39)

—The City has adopted a Conservation Combining District designed to control development deemed hazardous to unstable slopes. It is to be applied to slopes in excess of 30%.
(FINDING 9)

—The City has adopted an Excavation and Grading Ordinance designed to control excavation and grading on steep and unstable slopes and in those areas susceptible to environmental damage as a result of such activities. Engineering geology reports are required as a result of the ordinance whenever, in the opinion of the Planning Director, the grading operation threatens life or property.
(FINDING 9)

b. New Policies

—Require site specific geologic investigations for new residential development in excess of four units in known potential liquefaction areas.
(FINDING 3)

—Require site specific geologic investigations for new commercial, industrial, public and semi-public structures in known potential liquefaction areas.
(FINDINGS 1,5,22,27 and 29)

—Require site specific geologic investigations for the Pogonip Area as a part of environmental analysis for any future development proposals.
(FINDING 9)

—Establish policy requiring the adoption of revised Uniform Building Code (UBC) every three years, or as often as a new edition is made available, to ensure upgrading of seismic design standards for new structures.
(FINDINGS 1,3,22,25,27 and 29)

—The City should continue its active policy to initiate through the Uniform Code for the Abatement of Dangerous Buildings, Uniform Housing Code, Fire Prevention Code and the Uniform Buidling Code, the abatement of buildings susceptible to severe earthquake and fire damage. This policy should reflect a long-range approach in order to avoid economic hardship and/or dislocation problems. Structures should be allowed to remain as is, whenever possible, if their occupancy is significantly reduced or their use is made less critical. In addition, special attention should be given to the preservation of buildings of historic or aesthetic value; they should be strengthened rather than eliminated, whenever possible.
(FINDINGS 1,13,37 and 39)

—Reevaluate structural safety of all existing emergency use structures, such as hospitals, schools and public safety centers, after the adoption of each edition of the UBC and upgrade structures when necessary and appropriate.
(FINDINGS 27,29,31 and 37)

—Arrange for and designate alternate emergency use structures in non-hazard-prone areas.
(FINDINGS 27 and 31)

—Encourage Red Cross to continue to investigate existing and proposed emergency care structures for seismic and flood hazard mitigation features.
(FINDING 31)

—Sewer pipe, water pipe, and water pipe extension joints used in seismic hazard areas should be upgraded as technical advances are made in the design of such materials.
(FINDING 24)

—The future designation and construction of water pipe locations through the seismic- and flood-prone areas should be dispersed rather than concentrated, thereby reducing the impact of individual pipe breakage.
(FINDING 24)

—Actively promote public awareness programs by providing technical and policy information regarding geological and seismic hazards to the general public, interested persons, and prospective developers.
(FINDINGS 1,3,5,13 and 38)

The foregoing seismic safety policies conform—to the extent possible under City jurisdiction—to the geologic hazard policies contained in the proposed 1975 California Coastal Zone Conservation Commission Coastal Plan.

2. The following policies are designed to mitigate cliff retreat hazard findings made in Chapter III.

a. Existing Policy

—Environmental impact review is required on a selective basis for proposed developments that require special foundations near coastal bluffs and/or for proposed developments that would be threatened by cliff retreat.
(FINDINGS 11 and 17)

b. New Policy

—Require site specific geologic investigations for all development within one hundred feet of existing coastal bluffs in the cliff retreat areas.
(FINDINGS 11 and 17)

The foregoing cliff retreat hazard policies conform to the bluff top policies contained in the proposed 1975 California Coastal Zone Conservation Commission Coastal Plan.

3. The following policies are designed to mitigate flood hazard findings made in Chapter III.

a. Existing Policy

—The City has adopted a Flood Plain District and has applied it to the two unprotected floodways in the City. It was adopted in conjunction with the National Flood Insurance Program designed to regulate development in flood plains, thereby reducing risk to life and property.
(FINDINGS 4 and 14)

b. New Policies

—A plan should be written to ensure early warning to the maximum extent possible for evacuation of areas susceptible to inundation from Newell Creek Dam failure.
(FINDINGS 2,4,6,14 and 36)

—The tsunami inundation area evacuation plan should be revised periodically to reflect the most current evacuation procedures contained in the Civil Defense and Disaster Operational Plan.
(FINDINGS 2,4,12 and 14)

—A flood warning system should be instituted for neighborhoods in the Bay Street Reservoir inundation area.
(FINDINGS 8,16 and 35)

—A system should be devised to effect immediate evacuation of Bayview School should there be a structural failure of the Bay Street Reservoir.
(FINDING 33 and 35)

—Keep current a plan for the timely relocation of the Downtown Fire Station equipment to East and West Stations, for situations when flooding is eminent in the downtown area.
(FINDING 30)

—A channel maintenance program for the San Lorenzo River should be developed and implemented to ensure the maintenance of the flood flow capacity of the levee system, with consideration being given to the natural environment to the maximum extent possible.
(FINDING 23)

—Initiate bridge patrol activities at the time of early flood warning to prevent debris dam build-up at San Lorenzo River bridge locations.
(FINDINGS 21, 23 and 36)

—Inventory and maintain adequate road-clearing equipment and sandbag materials.
(FINDINGS 19,20 and 23)

—The levee system around the sewage treatment plant should be inspected periodically and maintained in a condition reflecting a low-risk situation.
(FINDING 26)

—Designate and equip additional alternative emergency centers in non-flood hazard areas.
(FINDING 28)

—Actively promote public awareness programs by providing technical and policy information regarding flood hazards to the public in general, interested persons, and prospective developers.
(FINDINGS 4 and 14)

The foregoing flood safety policies conform—to the extent possible under City jurisdiction—to the flood hazard policies contained in the proposed 1975 California Coastal Zone Conservation Commission Coastal Plan.

4. The following policies are designed to mitigate fire hazard findings made in Chapter III.

a. Existing Policies

—The Fire Department is currently pursuing an active fire prevention program.
(FINDINGS 7,10,15 and 18)

—Environmental impact review is required for developments that need special fire protection or developments that increase the fire hazard.
(FINDINGS 7,10.15 and 18)

b. New Policies

—Require fire prevention accountability for new development in the neighborhoods susceptible to wild fires.
(FINDINGS 7,10.15 and 18)

—Where preservation of fire-prone vegetation in currently undeveloped areas is deemed desirable and appropriate, development setbacks should be required as determined by the Fire Department on a project-by-project basis.
(FINDINGS 10 and 15)

5. The following policies are designed to improve City disaster planning in the City and are based on findings made in Chapters III and IV.

a. Existing Policies

—The City has an adopted Civil Defense and Disaster Operational Plan. It was adopted by the State in June 1975, and is updated biannually. It is the basis for developing a City Emergency Response Plan.
(FINDINGS 12,19,20,21 and 32)

—A Medical Response Plan and an Emergency Welfare Services Disaster Plan have been developed for the entire County, including the City of Santa Cruz.
(FINDING 32)

—The City should continue to review and revise,on a periodic basis, the emergency response plan program based on the existing City Operation Plan.
(FINDING 34)

b. New Policies

—The Emergency Response Plan should include the following elements:

(1) Provision for beach patrol for warning purposes immediately after a tsunami early-warning message is received.
(FINDINGS12 and 34)

(2) Main and alternate emergency and evacuation routes.
(FINDINGS 19,20,21 and 34)

(3) Continued use of UCSC as an emergency medical facility on the west side of the San Lorenzo River.
(FINDINGS 32 and 34)

(4) Designation of emergency operation centers in non-liquefaction and non-flood-prone areas.
(FINDINGS 27 and 34)

(5) Review existing flood warning network and ensure complete and adequate dissemination of flood warning notification.
(FINDINGS 4,6,14,20,26,28,30 and 34)

—Existing packaged disaster hospitals and field hospitals designated for emergency situations should be inventoried and tested periodically to ensure their completeness and availability.

—All boats docked in the Santa Cruz Yacht Harbor should be encouraged to contain a radio receiver capable of receiving national weather service early-warning messages.

D. Implementation

The adoption of this Element will delegate seismic safety and safety policy responsibility to the appropriate agencies. The responsible agencies should incorporate policy implementing programs into their yearly work programs. In those cases where policy recommendations reflect an existing program, that program should be continued. Where policy recommendations indicate a need for new programs, such programs should be initiated to implement that policy.

The policies contained in this Element reflect four program categories:

1. Disaster Planning
2. New Development
3. Existing Development
4. Public Awareness

1. Disaster Planning: Many policies contained in this Element reflect a need to better prepare ourselves for an emergency situation. These policies are not easily implemented without an organized approach involving all responsible agencies.

A recommended approach to this task is to require a yearly review of all emergency response plans coordinated through the City Manager's Office and under the supervision of the County Civil Defense Director. In this way, the City would be assured that (1) the department heads would remain fully aware of their individual responsibilities, (2) the response plans would reflect a coordinated approach, (3) the response plans would reflect the latest thinking in emergency preparedness, and (4) recommended emergency-related capital expenditures would be in line with the changing needs of the community and be assured of annual review.

2. New Development: Policies designed to ensure that new development will reflect a low-risk situation are primarily geared toward the planning process. This process includes not only the processing of development applications through the Planning Department, but the implementation of the Capital Improvements Program (CIP).

Seismic safety and safety policy should be implemented on a daily basis. The Planning Department should require, as a matter of policy, geologic reports for residential (over 4 units), commercial and industrial development within liquefaction areas and within 100' of cliff retreat areas. The Building Division should maintain its policy of updating Title 18 of the Municipal Code by recommending the adoption of the Uniform Building Code (UBC) every 3 years, or as often as a new edition is published.

The Public Works and Water Departments should continue their policy to keep apprised of the seismic response of new sewer and water pipes and utilize the safest pipe where appropriate. The Water Department should

incorporate into its master plan a policy to disperse water pipes crossing the downtown area so that implementation of that plan, through the CIP, will reflect seismic and flood emergency preparedness.

The ongoing General Plan update program should include the policies contained in this Element as guidelines for future land use designations.

3. Existing Development: Policies designed to maintain or upgrade existing development in the City reflect a continuing need for building rehabilitation, abatement of hazardous structures, and adequate flood warnning for areas susceptible to inundation from tsunamis, river flooding, and water supply facility failure.

The mechanism for abatement and rehabilitation of all structures in the City is contained in Titles 18 and 19 of the Municipal Code. Title 18 contains the Uniform Code for the Abatement of Dangerous Buildings, the Uniform Housing Code, and the Uniform Building Code. Title 19 contains the Fire Prevention Code.

The Building Division's policy of abatement of dangerous buildings(including removal and/or upgrading) should be guided by the following priorities:

(1) Multi-residence or high-density residential use structures of un-reinforced masonry construction.

(2) Public assembly structures of un-reinforced masonry construction.

(3) Multi-residence or high-density residential use structures other than priority "one" structures.

(4) Public assembly structures other than priority "two" structures.

(5) All other un-reinforced masonry structures.

(6) All other structures other than priority "one" through "five" structures.

A program to evaluate the safety and possible need for upgrading of City-owned emergency-related structures after each edition of the UBC is adopted, should be implemented.

Policies designed to improve the City flood-warning program should be implemented as soon as possible and should be a top priority in the development of the City Emergency Response Plan.

The City schools should amend their evacuation plan for Bayview School to include specific evacuation procedures in the event of a failure of Bay Street Reservoir.

4. Public Awareness: Policies designed to inform the public of seismic safety and safety land use problems are the responsibility of the Planning Department. The preparation of this Element is evidence of that fact and is in part implementing such a policy. The addition of the Seismic Safety and Safety Element to the General Plan assures public awareness, and City Council and Planning Commission consideration of natural hazards in short-term and long-term land use planning decisions. This assurance not only informs the public, but takes positive steps towards reducing the risks associated with the hazards.

Further steps to assure public awareness should include easy public access to the Element by making it available in all branches of the Library, at the Chamber of Commerce office, from the City Public Information Officer, and from the Planning Department.

E. Cost Analysis

A safer community does not come without cost but neither does a disaster. The policies in this Element represent increased expenditures in both time and money. Those expenditures, however, are designed to reduce or prevent even larger expenditures in the aftermath of an earthquake, flood, fire, or other hazardous occurrence. The old addage, "Pay now or pay later", rings true when planning for the possibility of a disaster. If you do not pay now in terms of responsible disaster planning, adequate site review, and proper maintenance, the cost later will include interest in terms of unnecessary loss of life, injury, and extensive property damage.

The specific costs reflected in the policies contained herein can be divided into two categories: cost to the City (staffing and capital expenditures), and cost to the public in general (development costs and maintenance costs).

Policies reflecting more staff time such as site specific geological review, do not create an immediate need for more Staff. However, they do represent an incremental increase in staff responsibility and work load. As a result these policies could affect the requirement for possible increases in personnel at a later date.

Policies reflecting capital improvement, operation and maintenance expenditures, such as new water and sewer pipes and the San Lorenzo River levee dredging, represent substantial costs to the City and those costs should be determined for their inclusion in the City's operating and capital improvement budgets.

General public costs are primarily reflected in policies designed to make private construction safer. Geological and soils reports, current Uniform Building Code standards, abatement of dangerous buildings, and fire prevention accountability all represent added costs to the general public, including the developer. Such costs will ultimately reflect increased construction costs for housing, commerce and industry.

CHAPTER V - ENVIRONMENTAL REVIEW

Negative Declaration

The Seismic Safety and Safety Element is a statement of policy intended to establish a responsible approach for dealing with hazards in Santa Cruz. The City is subject to a variety of hazards, any of which could affect a large segment of the community at any time. Policies to better prepare the City for such an event are developed in the Seismic Safety and Safety Element and are intended to reduce loss of life, injury, and property damage. For this reason, this Element represents a beneficial impact and not a significant adverse impact to Santa Cruz. Further analysis to substantiate this declaration of no significant impact is discussed in conjunction with each policy area.

1. Seismic Policy - Seismic policy includes the requirement that selected development proposals in liquefaction areas be accompanied by geologic investigations; that the City maximize utility of the Uniform Building Code in dealing with structural safety; that construction and maintenance of public utility facilities conform to high seismic design standards; that key emergency facilities be appropriately located in the event of a seismic event ; and that the public be made aware of their susceptibility to the seismic hazards as they exist in Santa Cruz. Such policy in no way increases potential adverse impact to the physical or social environment of Santa Cruz.

2. Coastal Bluff Policy - Coastal bluff policy, primarily reflected in the requirement that development proposals within 100' of the Santa Cruz ocean and bay bluffs be accompanied by a geologic investigation, indicates a concern not only for the bluffs but also for the people and property that may occupy the bluffs. Such policy will act as a mitigating measure to the potential adverse impact represented by coastal development.

3. Flood Hazard Policy - Flood hazard policy includes the development of evacuation plans for flood-prone areas; the development and implementation of a channel maintenance program for the San Lorenzo River to maintain the capacity of the levee system; and public awareness programs to ensure that the citizens of Santa Cruz would be prepared in the event of a flood. With the inclusion of the City's existing regulations for development in flood-prone areas (reflected in the flood plains districts), the Seismic Safety and Safety Element's flood hazard policies act to mitigate the adverse impacts of flood situations.

4. Fire Hazard Policy - Fire hazard policy requires that, for proposed developments in and around fire-prone areas, consideration must be given to fire-mitigating measures;

measures to be approved by the Fire Department.

5. Disaster Planning Policy - Emergency readiness acts to prevent the compounding of injury and loss of life in the event of a disaster. The disaster planning policy contained in the Seismic Safety and Safety Element focuses on the continued improvement of the City emergency response plan, thereby maintaining a high state of readiness and ensuring measures to reduce loss of life, injury, and property damage.

APPENDIX A

DAMAGE IN SANTA CRUZ COUNTY FROM HISTORIC EARTHQUAKES

The following is a summary of reported damage in Santa Cruz County from Historic earthquakes (Lawson, 1908; NOAA, 1973; Department of Water Resources, 1967; California University Bulletin of the Seismographic Stations, 1936; Santa Cruz Sentinel, numerous issues from 1945 to the present). The intensity[1] is given for all earthquakes; magnitude[2] is given only for more recent earthquakes.

October 8, 1965. Epicenter - Santa Cruz Mountains. Intensity-VIII-IX. Chimneys fell on the Santa Cruz Gap Road. The earth opened and boulders obstructed the road at Mountain Charley's.

March 30, 1885. Epicenter - southeast of Hollister. Intensity-VII. Cracks developed in the banks of the Pajaro River.

April 24, 1890. Epicenter - Monterey Bay region. Intensity-VII. Chimneys toppled in Watsonville. Fissuring occurred in the San Andreas Fault zone near Chittenden. Damage to the railroad resulted from settling of the ground and displacement of a bridge.

April 30, 1899. Epicenter - Watsonville. Intensity-VII. Chimneys and cemetery monuments were damaged at Green Valley.

July 6, 1899. Epicenter - Watsonville. Intensity-unknown. Chimneys in Watsonville collapsed.

April 18, 1906. Epicenter - Marine County. Intensity-VI. Magnitude-8.25. Displacement of up to five feet occurred along the San Andreas Fault in Santa Cruz County as compared to movement of 20 feet in Marin County. There was five feet of offset in the railway tunnel of Wright's Station. Approximately one-half mile from Wright's Station, the Morrell house was split in two by movement along the Fault. In the southern part of the County, movement along the Fault at Chittenden resulted in the displacement of the railway bridge piers. Numerous landslides, both large and small, were triggered by the earthquake in the Santa Cruz Mountains. Among the more notable slides was the Hinckley Creek slide which killed nine men who were sleeping in the Loma Prieta Mill bunkhouse. A large slide on Deer Creek destroyed acres of virgin timber, partly buried Hoffman Shingle Mill, and killed one man. A smaller slide on Bear Creek buried a hut and killed one man. In the summit area, numerous slides occurred off the western slope of Skyland Ridge, and Burrell Creek narrowed as a result of sliding. Slides on both sides of Aptos Creek extended for three-quarters of a mile. Mountain roads east and northeast of Corralitos were rendered impassable by landslides. Cracks developed in the banks of the San Lorenzo and Pajaro Rivers as a result of liquefaction. Throughout the County, plaster and chimneys cracked and/or fell, furniture and small objects moved, water tanks fell, and water mains were broken, tops of trees broke and fell, people and animals were thrown to the ground, and communications were cut off. Most damage to buildings was limited to plaster and chimneys. Some buildings, mostly brick, sustained damage to their superstructures and others fell from their foundations. The most badly damaged building in downtown Santa Cruz was the courthouse; its tower fell and the rear wall collapsed.

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[1]Based on Mercalli Intensity Scale (see Appendix B)
[2]Based on Richter Scale (see Chapter II)

November 8, 1914. Epicenter - Santa Cruz Mountains. Intensity-VII. Near Laurel, Chimneys toppled and objects were thrown from shelves. About 4 miles northwest of Laurel, two water pipes were broken.

October 22, 1926. Epicenter - Monterey Bay. Intensity-VIII. At Santa Cruz, chimneys were destroyed and old brick buildings were damaged. The lighthouse of Ano Nuevo Island was damaged.

December 30, 1934. Epicenter - Santa Clara area. Intensity-V-VI. The big Santa Cruz water supply pipeline broke near the Antonelli artichoke ranch. The quake was believed to have caused a number of slides on the Waddell Beach section of Highway 1 and the undermining of a portion of West Cliff Drive.

June 22, 1947. Epicenter - Gilroy. Intensity-VI. Magnitude-5. Hecker Pass and Chittenden Pass were closed by slides.

December 16, 1953. Epicenter - Watsonville, Intensity-VI. Magnitude-4.6. There was slight damage. Five miles west of Chittenden Junction, boulders crashed onto the road.

April 22, 1954. Epicenter - east of Watsonville. Intensity-VI. Magnitude-5.2 At Aptos, plaster fell, walls cracked, and dishes broke.

April 25, 1954. Epicenter - east of Watsonville. Intensity-VIII. Magnitude - 5.25. Slides blocked Chittenden Pass Road. The Bank of America building in Watsonville sustained a crack in the ceiling and one wall, fallen concrete, and plaster damage. The plaster was cracked badly at City Hall and the flagpole toppled from the Porter Building in Watsonville. Several houses east of Watsonville were seriously damaged. A water main in Watsonville was broken. Irrigation lines in the southern part of the County were broken. The Interlaken District was the hardest hit; in a two-block stretch along Cutter Drive, not a single chimney remained undamaged.

August 12, 1954. Epicenter - east of Watsonville. Intensity-VI. Slides occurred on a road near Logan.

March 2, 1959. Epicenter - near Gilroy. Intensity-VI. Magnitude-5.3. Minor landslides occurred on Chittenden Pass Road and on Hecker Pass Road. A piece of cornice fell from the ceiling in the Superior Court Chambers of the County Courthouse. A 20-foot long crack developed in the Water Department Office in Watsonville City Hall.

September 14, 1963. Epicenter - vicinity of Chittenden and Soda Lake. Intensity-VII. Magnitude-5.4. Minor damage occurred along the San Andreas Fault east of Watsonville. The flood of one house moved from the wall while the ceiling of another house separated from its wall. The footings of a highway bridge across the Pajaro River were damaged slightly. Plaster and chimneys cracked. Water pipes broke. Landslides occurred in the Soda Lake and Pajaro Gap areas. A slide was reported on Rogge Lane near Watsonville.

November 15, 1964. Epicenter - north of Watsonville. Intensity-VII. Magnitude-5-5.2. Chimneys were damaged, large furniture moved, and objects fell from shelves in the Corralitos area. Minor damage also occurred in Santa Cruz and Watsonville.

October 14, 1966. Epicenter - Watsonville area. Intensity-VI. Magnitude-4.2. In Watsonville, plaster cracked and furniture moved.

September 7, 1967. Epicenter - near Corralitos. Intensity-VI. Magnitude-4.7. Merchandise and small objects fell from shelves.

December 18, 1967. Epicenter - Corralitos. Intensity-VI. Magnitude-5.2. Plaster, chimneys, and windows were damaged at Corralitos and Watsonville.

March 21, 1968. Epicenter - Corralitos area. Intensity-V. Magnitude-4.3. In Corralitos small objects fell.

August 3, 1970. Epicenter - Carmell Valley area. Intensity-VI. Magnitude-4.7. A smoke detection head of Cowell College broke. Telephones were knocked out in some areas. Breakage of a 12-inch water main on Mission Street on August 8 was attributed to the August 3 quake.

APPENDIX B

THE MERCALLI INTENSITY SCALE (MODIFIED 1931)

I Not felt by people, except under especially favorable circumstances. However, dizziness or nausea may be experienced.

Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly.

II Felt indoors by a few people, especially on upper floors of multi-story buildings, and by sensitive or nervous persons.

As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended.

III Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases.

Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly.

IV Felt indoors by many, outdoors by few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy, or heavily loaded trucks. Sensation like a heavy body striking building, or the falling of heavy objects inside.

Dishes, windows and doors rattle; glassware and crockery clink and clash. Walls and house frames creak, especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary automobiles rock noticeable.

V Felt indoors by practically everyone, outdoors by most people. Direction can often be estimated by those outdoors. Awakens many, or most sleepers. Frightens a few people, with slight excitement; some persons run outdoors.

Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerable. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop, or run fast or slow. Small objects move, and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly.

VI Felt by everyone, indoors and outdoors. Awakens all sleepers. Frightens many people; general excitement, and some persons run outdoors.

Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes and glasses, and a few windows break. Knick-knacks, books and pictures fall. Furniture overturns in many instances. Heavy furnishings move.

VII Frightens everyone. General alarm, and everyone runs outdoors.

People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged.

VIII General fright and alarm approaches panic.

Persons driving cars are disturbed. Trees shake strongly, and branches and trunks break off (especially palm trees). Sand and mud erupts in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperatures of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings, with some partial collapse; heavy in some wooden houses, with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet grounds and steep slopes crack to some extent. Chimneys, columns, monuments and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns.

IX Panic is general.

Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other masonry buildings - - some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged and underground pipes sometimes break.

X Panic is general.

Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally on beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged, and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures, and their foundations, are destroyed. Railroad rails bend slightly. Pipe lines buried in earth tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces.

XI Panic is general.

Disturbances in ground are many and widespread, varying with the ground material. Broad fissures, earth slumps, and land slips develop in soft, wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures, especially near shock centers, great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large, well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly and some thrust endwise. Pipe lines buried in earth are put completely out of service.

XII Panic is general.

Damage is total, and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied, and numerous shearing cracks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock, and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air.

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